ANALYSIS OF ENERGY CONSUMPTION AND PRODUCTION PATTERN IN DHANWAS : A SURVEY REPORT

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CONTENTS

Page No.

LIST OF TABLES vi

Abstract 1

INTRODUCTION 2

Need for Micro Studies 1

Relevance of Micro-study in Dhanawas for TERI 1

The Need for a Second Census Survey in Dhanawas 2

The Scope of Information Needs 3

Objectives of the Study 4

Methodology 4
   The questionnaire 4
   The size of the sample and duration of the study 6

DATA ANALYSIS AND RESULTS 6

Norms for Categorization of the Families 6

Family Size 9

Household Education Level 10

Land Particulars 11

Village Agricultural Practices 13

Cropping Pattern for the Rabi Season 14

Livestock Particulars 15

BIOMASS RAMIFICATIONS 17

Biomass Availability and Consumption 17

Time and Source of Collection of Biomass 21

DOMESTIC SECTOR 25

Domestic Energy Consumption 25

Energy for Cooking 30

Energy for Water-heating 32

Energy Consumption for Lighting 35

AGRICULTURE SECTOR 38

Energy in Agriculture 38

Agricultural Activity - Land Preparation 39
Tractor use 39
Energy for land preparation 41

Agricultural Activity - Irrigation 44
Use of pumpsets 44
Energy for irrigation 46

Agricultural Activity - Threshing 49
Use of threshers 49
Energy for threshing 50

Fertilizer 51

Normative Data for Pumpsets, Tractors and Threshers 54

EFFECTS OF MECHANIZATION ON CROP PRODUCTIVITY 55

Regression Analysis 60

CHANGES IN ENERGY CONSUMPTION PATTERN IN DHANAWAS 63

Pattern of Household Energy Consumption 63

Pattern of Agricultural Energy Consumption 63

MAIN FINDINGS 69

Appendix I 86

Appendix II 87

Appendix III 88

Appendix IV 89

LIST OF TABLES

Page No.

Table 1 : Calorific Value of the Fuels Used 7

Table 2 : Distribution of the Household According to Size of the Land-owned 8

Table 3 : Distribution of the Households According to Size of the Land Cultivated 9

Table 4 : Average Family-size According to Land-owned Classification 10

Table 5 : Household Education Level According to Land-owned Classification 11

Table 6 : Distribution of Land According to Land-owned Classification 12

Table 7 : Agro-physical Resource Distribution in the Farms according to Land-owned Classification 13

Table 8 : Share of Area Under Different Crops in Different Farm Categories According to Land Cultivated Classification 14

Table 9 : Distribution of Livestock According to Land-owned Classification 15

Table 10 : Distribution of Households According to Livestock size 16

Table 11 : Per Capita Monthly Pulse Consumption According to Land-owned Classification 18

Table 12 : Availability and Consumption of Wet Cowdung for Rabi Season According to Land-owned Classification 20

Table 13 : Availability and Consumption of Crop-residue for Rabi Season According to Land-owned Classification 21

Table 14 : Time Spent on Collection of Biomass Fuels 22

Table 15 : Average Time Spent on Fuel Collection per Family During Rabi Season 23

Table 16 : Sources of obtaining Cowdung According to Land-owned Classification 24

Table 17 : Sources of obtaining Crop-residue According to Land-owned Classification 24

Table 18 : Source of Collection of Firewood According to Land-owned Classification 26

Table 19 : Monthly Household Energy Consumption according to Land-owned Classification 26

Table 20 : Per Capita Monthly Household Energy Consumption According to Land-owned Classification 28

Table 21 : Distribution of Households Using Different Fuels According to Land-owned Classification 29

Table 22 : Monthly Household Energy Consumption for Various End-uses According to Land-owned Classification 31

Table 23 : Monthly Household Energy Consumption for Cooking According to Land-owned Classification 31

Table 24 : Average Monthly Energy Consumption for Cooking According to Land-owned Classification 32

Table 25 : Distribution of Households Using Different Fuels for Cooking 33

Table 26 : Average Monthly Energy Consumption For Water-heating According to Land-owned Classification 34

Table 27 : Monthly Household Energy Consumption for Water-heating 34

Table 28 : Distribution of Households using Different Fuels for Water-heating 36

Table 29 : Monthly Household Energy Consumption for Lighting According to Land-owned Classification 36

Table 30 : Average Monthly Energy Consumption for Lighting According to Land-owned Classification 37

Table 31 : Disribution of Households using Different Fuels for Lighting According to Land-owned Classification 38

Table 32 : Distribution of Household According to Size of Land Cultivated 39

Table 33 : Tractor Use According to Size of the Land Cultivated 40

Table 34 : Distribution of Households using Different Methods of Land-Preparation According to Size of the Land Cultivated 43

Table 35 : Average Machine Hours/Animal Pair Hours Used Per Acre According to Size of the Land Cultivated 43

Table 36 : Average Human Hours Used Per Acre According to Size of the Land Cultivated 44

Table 37 : Average Energy Consumed Per Acre for Land Preparation According to Size of the Land Cultivated 45

Table 38 : Use of Pumpsets According to Size of the Land Cultivated 46

Table 39 : Distribution of Households Employing Electric and Diesel Pumpsets According to Size of the Land Cultivated 48

Table 40 : Inputs for Agricultural Activity - Irrigation According to Size of the Land Cultivated 48

Table 41 : Average Energy Consumption Per Acre for Irrigation According to Size of the Land Cultivated 50

Table 42 : Use of Threshers According to Size of the Land Cultivated 51

Table 43 : Energy Input for Threshing According to Land Cultivated Classification 53

Table 44 : Energy Consumption for the Agricultural Activity - Application of Fertilizer 54

Table 45 : Normative Data for Pumpsets, Tractors and Threshers 56

Table 46 : Mustard Crop Yield on Various Land Categories and According to the Size of the Land Cultivated 57

Table 47 : Wheat Crop Yield on Various Land Categories and According to Size of the Land Cultivated 61

Table 48 : Results of Uni-variate Regression Analysis 64

Table 49 : Trends in Domestic Energy Consumption Pattern in Dhanawas 66

Table 50 : Trends in Domestic Energy Consumption Pattern in Dhanawas 72

Table 51 : Listing of Activities and Energy Sources Considered in the Study 73

Table 52 : Dhanawas Energy Source - Activity Matrix for Rabi Season 74

Table 53 : Dhanawas Energy Source - Activity Matrix 76

ABSTRACT

Information is crucial for development planning. It facilitates decision making and improves the decision making process. This also applies to energy planning for a village. Thus, with the prime objective of obtaining data that would assist in formulating a location-specific action programme for energy use, two comprehensive surveys were conducted in village Dhanawas in Haryana state, first in the year 1984 and again in the year 1986. These surveys quantified the energy demand for agricultural and domestic activities, with explicit reference to various categories of farmers. The reason for repeating the survey in 1986 primarily was to understand the dynamics of the rural energy set-up. It was felt that the variables that influence a village's energy supply and demand pattern are intrinsically time-bound; one such variable is seasonality and some of the other variables could be income level, economic development etc., which change with time. With variations in these factors, the interaction between energy and any subsystem, say, agriculture, would change, the inter-relationships between the subsystems, say, fuel-fodder-fertilizer relations,would change. With a view to this, two surveys were carried out in Dhanawas and detailed results of the second survey and a comparison of the findings of the first and second surveys are presented in this study.

Keywords: Rural Energy, Survey, Energy Demand, Energy Supply

INTRODUCTION

Need for Micro Studies

In view of the tremendous heterogeneity of rural systems in terms of development, resource endowment and socio-cultural attributes, it is a trying task to outline a general energy strategy which will not only be appropriate for the rural areas, but also acceptable to the people living in these areas. Further, energy problems and user priorities differ from one place to another. Each area, therefore, needs to be considered in the light of its peculiar local characteristics. Hence, while formulating a location-specific action programme for rural energy use, the village energy study is of paramount importance.

It is essential that these micro-studies reflect the local pattern of energy sources and their use; they should also, to some extent, quantify the causal relationships between the income or socio-economic status of households and the observed pattern and level of fuel consumption. Further, these studies should also provide a clue regarding the scope for conservation and related technological interventions.

Relevance of Micro-study in Dhanawas for TERI

The efforts of TERI's research, among other fields, are focussed on the rural area, as this continues to be the dominant sector in India, and a majority of its population is rural. Keeping this in view, TERI has established a Rural Energy Research and Extension Group which aims to study energy problems of rural communities and tries to provide possible solutions. Against this background, village Dhanawas, located in the Gurgaon district of Haryana, was selected in March 1984. TERI's aim is to help in making this village self-reliant in energy. To achieve this, an integrated energy management programme is being implemented in Dhanawas. Prior to the actual implementation of this programme, a detailed study was carried out in May 1984, which aimed at the following:

(i) quantifying energy supply and demand in the village;

(ii) to make an estimate of future demand for specific end-uses;

(iii) project supply for specific energy forms by specified end-uses; and

(iv) to evaluate the gap between projected demand and supply.

All the above objectives were successfully met in the first study (1).

The Need for a Second Census Survey in Dhanawas

Micro-level energy surveys aiming at understanding the dynamics of rural energy supply and demand patterns, are usually long-term undertakings. A number of the variables to be studied are intrinsically time-bound. The significance of seasonality in consumption patterns and in the availability of fuels in rural areas, has been recognized. For this reason, field work must be carried out over a period of time sufficient to capture variations due to seasonality. Moreover, when physical data on consumption and supply are being sought, rural energy surveys should be carried out over a full agro-climatic cycle. Economic analysis to determine income and price elasticities of fuel demand will seldom be possible in the absence of adequate time series data. Thus, the survey design must be such as to allow periodic repetition. Keeping this in mind, a second round of survey was considered necessary. However, it should be noted that in this report, no attempt has been made to estimate income or price elasticities, as two-point data would not give meaningful estimates.

The Scope of Information Needs

Once the need for a second round of survey is established, the requisite data should be examined carefully. Besides obtaining time-series data on some of the variables, the scope of the information sought should also illustrate the energy flows and associated problems of demand and supply and their inter-relationships with various subsystems defined on the basis of the socio-economic status. One such inter-sectoral dependency could be among food, fuel, fodder and others. Considering this, the survey aimed at obtaining information on the following;

- the pattern of consumption of all biomass fuels among all socio-economic groups;
- information on the resource base (this would include the availability of crop residue and cowdung within the village itself); and
- data on land use and cropping patterns.

Objectives of the Study

The study addressed itself to the following issues:

i. To analyze the pattern of energy utilization for various activities by different economic categories of a village community;

ii. to bring out the differences, if any, in energy use and the pattern of domestic energy consumption vis-a-vis differences in economic status, through analysis of the cross-sectional data obtained from a field survey;

iii. to analyze the variation in energy consumption in agriculture with regard to the size of the land cultivated; and

iv. to assess the biomass availability in the village.

Methodology

The questionnaire

This was designed keeping in mind all the points that emerged from the objective of the study and the scope of the information sought. The questionnaire that was eventually used for the survey in Dhanawas was divided into two schedules: i) village, and ii) household.

The village schedule established the identity of the village by seeking information regarding its population, number of households, net owned and cultivated area, its distance from block and district headquarters, and also different energy

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The village schedule established the identity of the village by seeking information regarding its population, number of households, net owned and cultivated area, its distance from block and district headquarters, and also different energy sources that are being used in the village. However, as the information was already available from the previous survey, this schedule was not used.

The questions in the household schedule were framed to provide an insight into the energy consumption pattern in the domestic and agricultural sectors. Both biomass and non-biomass energy sources were included. The schedule was designed for obtaining detailed particulars of a household with regard to its land-holding, livestock, food grain and energy consumption, farm output, and fertilizer and labour inputs.

A method of repetitive questioning was adopted for this survey: i.e. within the questionnaire itself, an estimate of a particular variable was asked for, both directly and indirectly, to check the consistency of the information given. Further, to ensure the reliability of the data obtained, enough physical measurements were made on the spot: eg. the actual weight of a _tasla_ (a pan in which dung is collected), head-load of crop residue brought from the field, etc. In cases where a high variation was observed between the respondent's response and statistical-mean of the actual observations the latter was used.

This questionnaire was essentially the same as the one used for the first census survey, though some modifications were made in accordance with the feedback obtained during the first survey.

The size of the sample and duration of the survey

Since Dhanawas consists of only about 130 households, and is not a very big village, it was decided to cover all the households for this survey. House-to-house investigations were carried out by 4 field assistants who had conducted the first survey as well. These investigators were local residents, who interviewed members of a household and accordingly filled in the prescribed questionnaire with the responses. The field work was supervised by the TERI staff.

The first survey was conducted in the months of May-June, 1984, or during the pre-monsoon period. For the second survey, the post-monsoon period - September-October 1985 - was chosen.

DATA ANALYSIS AND RESULTS

Norms for Categorization of Families

This report represents energy quantities in energy units: kCal. Data were gathered on the basis of physical quantities of inputs and fuel used, employing a well-designed and pre-tested questionnaire. These were then transformed into energy values by using appropriate conversion factors as presented in Table 1.

The household and agriculture sectors being the largest consumers of energy, the evaluation of energy use pattern was restricted to these two sectors only.

Table 1: Calorific Value of The Fuels Used

Fuel	Unit	Calorific value (kCal)
Cowdung (Dry)	kg	2130
Crop residue	kg	3500
Firewood:		
1.logs	kg	4750
2.twigs	kg	4700
Kerosene	l	8547
Electricity	kWh	861
Coal/coke	kg	5770
Diesel	l	8926

Source: NCAER, "Rural Energy Consumption in Northern India", 1981.

The present study highlights the consumption pattern of various forms of energy: source-wise and use-wise. The household sector analysis includes energy consumption in domestic cooking, water-heating and lighting. The level of domestic energy utilization was analyzed in terms of per capita and per household consumption. Source-wise contribution of various fuels was assessed in absolute as well as percentage terms. The energy inputs considered in the agricultural production system were: farmyard manure, fertilizer, human labour, animal power, diesel and electricity. The system was limited to on-farm activities only, and post-harvest operations (except for threshing), eg. drying, milling and marketing, were not included. Evaluation of farm energy use involved the consideration of energy use per acre of gross cropped area.

The income-level of a household is expected to have a direct bearing on the socio-economic variables such as family size, level of education, economic status, livestock population, etc. and also on the consumption of domestic energy sources. In our last census survey, we had found that it is not possible to get a realistic estimate of the family income; hence, for the present study, we have categorized the households on the basis of the total land owned by the family. Table 2 shows the distribution of the household according to land-owned classification. Artisans, persons in service, etc. have been covered under the 'Landless' category.

Table 2: Distribution of the Household According to Size of the Land Owned

Farmers' category	Size of landholding (acres)	Households Nos.	Households per cent	Average size of land owned per household (acres)	Total land owned (acres)
Big	more than 10	18	15.52	18.72	337
Medium	5 - 10	13	11.21	8.04	104.5
Small	2.5 - 5	21	18.10	4.00	84.0
Marginal	upto - 2.5	21	18.10	1.94	40.75
Landless	-	43	37.07	-	-
All		116	100.00	4.88	566.25

On the other hand, for agriculture-related analysis, the household categories have been defined on the basis of the total land cultivated. The justification for differentiating the classification norms for domestic and agricultural sectors is that the domestic energy consumption has been found to be a factor of the economic status of the family; agricultural energy use is a factor of the size of the land cultivated. However, the norms for the various categories of farmers are the same for both land-cultivated and land-owned classifications. For instance, a big farmer under land-owned classification would necessarily be possessing more than 10 acres of land and the one under land-cultivated would be growing more than 10 acres. It should, however, be pointed out that there might not be a one-to-one correspondence vis-a-vis the number of families falling under the two classifications.

Table 3 presents the distribution of the households according to land-cultivated classification. It can be noticed that the number of cultivators are less than the number of land owners.

Table 3: Distribution of the Households According to Size of Land Cultivated

Farmers' Category	Size of land cultivated (acres)	Households Nos.	Households per cent	Average land cultivated per household (acres)	Total land under cultivation
Big	> 10	19	16.38	17.11	325.00
Medium	5 - 10	10	8.62	7.80	78.00
Small	2.5 - 5	17	14.66	3.94	67.00
Marginal	upto 2.5	16	13.79	1.73	27.75
Non-cultivating	-	54	46.55	-	-
All		116	100.00	4.29	497.75

Some selected socio-economic parameters along with an analysis of the group differences are discussed below.

Family Size

In Dhanawas, big farmers have an average family size of 9.7 which is significantly larger than any other category. The average for the village as a whole is 7.18 and the average for the landless works out to 6.26. The difference in the family-size among the various categories may be due to the prevalence of the joint-family system in the households of the bigger farmers. Table 4 gives the average family size for different household categories. A positive correlation between the size of the household and land owned can be distinctly observed.

Table 4: Average Family-size According to Land-owned Classification

Farmers' category	Population			Average size of the household
	Young	Adults	Total	
Big	49	125	174	9.67
Medium	27	77	104	8.00
Small	35	104	139	6.62
Marginal	47	100	147	7.00
Landless	99	170	269	6.26
All	257	576	833	7.18

Household Education Level

An analysis of the educational status of the various categories has been made, as this is expected to have some influence on their income as well as on their energy consumption pattern. This was determined by multiplying the weightage of a given education level (i.e. no education 0, primary 1, middle 2, high 3, graduate 4 and post graduate 5) by the number of members having up to that level of education, and dividing the sum of the products by the total number of family members with the potentiality of having formal education (i.e. all members above five years of age). Table 5 presents the educational status for different household categories.

Table 5: Household Education Level According to Land-owned Classification

Farmers' category	Level of education		
	Children	Adults	All
Big	0.91	1.08	1.03
Medium	0.55	0.91	0.78
Small	0.91	0.86	0.87
Marginal	0.68	0.90	0.80
Landless	0.68	0.95	0.85
All	0.74	0.95	0.87

There is no consistent trend to be seen among the various farmers' categories. However, it is noticeable that the big farmers have above-average formal education. In the landless category, the educational level for adults is noticeably higher than that of the other categories, barring that of the big farmer -- this category has the maximum number of matriculates; however, the ratio with the big farmers is 1 : 8.

Land Particulars

Table 6 provides a general overview of the distribution of land as pastures, orchards or fallow land for the next cropping season, i.e. Kharif. It was observed that leasing of land is not the prerogative of any particular category of households, although in big farmers' families, in terms of share, this transfer of land is much less intensive. Table 6 indicates that of the total land available, 98.36 per cent is cultivable. The percentage share of cultivable land was found to be the least for the big farmers' category.

Table 6: Distribution of Land According to Land-owned Classification

Farmers' category	Size of land-holding (acres)	Total land		Total land available	Pasture land	Fallow land	Orchard	Cultivable land
		leased in (% of total (land owned)	leased out	(acres)	(%age of total land available)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	[100-(5)-(7)]
Big	337.00	5.04	11.28	316.00	1.90	15.51	0.47	97.63
Medium	104.50	35.41	27.75	112.50	1.78	16.00	-	98.22
Small	84.00	19.05	25.00	78.5	-	3.80	-	100.00
Marginal	40.75	36.81	22.09	46.75	-	8.56	-	100.00
Landless	0.00	100.00	-	26.00	-	-	-	100.00
All	566.25	19.60	17.22	579.75	1.38	12.76	0.26	98.36

The per-capita cultivable land increases consistently with the farm-size. Though bigger farmers lease out substantial portions of their land, the per capita land available for cultivation to this category is almost 2.5 times more than the average for Dhanawas. The landless also engage in cultivating on the leased-in land, though on an average, they have the smallest plot size available to them.

Table 7: Agro-physical Resource Distribution in the Farms According to Land-owned Classification

Farmers' category	Cultivable land (acres) (i)	Average per HH cultivable area(acres) (ii)	Per capita cultivable land (acres) (iii)	Cropped area		Area irrigated (acres) (vi)	Irrigated (%age of cropped area) (vii)
				(acres) (iv)	% of cultivable land (v)		
Big	308.50	17.14	1.77	261.00	84.60	245.00	93.87
Medium	110.50	8.50	1.06	92.50	83.71	84.50	91.35
Small	78.50	3.74	0.56	75.50	96.18	70.50	93.38
Marginal	46.75	2.23	0.33	42.75	91.44	42.00	98.25
Landless	26.00	0.60	0.10	26.00	100.00	26.00	100.00
All	570.25	4.88	0.68	497.75	87.29	468.00	94.02

Note: i) Cultivable = total owned + leased in - leased out land - land under pasture - land under orchard + fallow land

ii) HH = household

Table 7 indicates that for the main cropping season - Rabi, smaller categories of farmers tend to cultivate the maximum of the land at their disposal. The big and medium farmers are observed to keep as much as 15-16 per cent of the cultivable land as fallow, to be used in the following season.

Comparison of the irrigation intensity indicates that marginal and tenant farmers have more area under irrigation than the first three categories of bigger farmers. The difference, though not very great, is consistent for all categories except the first. It would be interesting to look at the cropping intensity and irrigation intensity for the growing seasons and then to identify the factor to which the category-wise differences can be attributed.

Cropping Pattern for the Rabi Season

In Dhanawas, there are two major cropping seasons: **Rabi** (harvesting time March-April) and **Kharif** (harvesting time October-November).

Table 8: Share of Area Under Different Crops in Different Farm Categories According to Land Cultivated Classification

Unit: Per cent

Farmers' Category/Crops	Wheat	Mustard	Barley
Big	46.46	28.31	21.85
Medium	49.37	31.65	13.92
Small	73.88	17.16	5.97
Marginal	80.18	18.81	9.01
All	52.59	27.22	17.78

Table 8 presented above depicts the cropping pattern for the different categories of farmers, for Rabi only. Here, the categories have been defined on the basis of the total land cultivated.

The important crops in Dhanawas are wheat and mustard and together they constitute about 80 per cent of the gross cultivated area. Over 50 per cent of the area is cultivated under wheat and its percentage share increases with the decrease in the plot-size. In contrast, mustard crop is grown extensively in the bigger farmers' plot. Although mustard is the main cash-crop, the reason why smaller farmers prefer to grow wheat is that mustard is a rather unstable crop and highly sensitive to weather conditions. Wheat is a comparatively hardy crop and a lesser risk, financially. The other probable reason for the preference of smaller farmers to cover maximum area under wheat is that they may be growing wheat for their own consumption after which not much land is available for mustard.

Livestock Particulars

Ownership of livestock by a family is one of the major indicators of the energy resources available to a family and the village as a whole. In Dhanawas, the total population of the cattle is 406, 64 per cent being adults. Table 9 shows the distribution factor of livestock among the various farm categories in the village.

Table 9: Distribution Of Livestock According to Land-owned Classification

Farmers' Category	Av.per household ownership of cattle-heads			No. of families possessing cattle head(s)	Percentage of the families
	Adult	Young	Total		
Big	4.83	1.83	6.66	18	100.00
Medium	2.62	1.69	4.31	12	92.31
Small	2.19	1.38	3.57	21	100.00
Marginal	1.76	1.05	2.81	19	90.48
Landless	1.33	0.91	2.24	35	81.40
All	2.25	1.25	3.50	105	90.52

The above Table indicates a very high percentage of cattlehead ownership (90.52). The average ownership of cattle head(s) per household consistently increases with the size of the land owned. This trend is true for both adult and young cattleheads. With this trend, it has been established that the two energy-yielding assets -- land and livestock -- have a strong positive correlation. Thus, bigger farmers have much higher availability of both crop-residue and cowdung.

From the point of installing biogas plants in the village, it is essential to look at the distribution of households by the size of the livestock owned. Table 10 provides this information. The families owning more than 4 cattleheads can be counted as having potential for the installation of a 2 cu.m biogas plant.

Table 10: Distribution of Households According to Livestock Size

Cattle size (Range)	Number of households	Percentage of total households
Upto 2	28	24.14
2-4	50	43.10
4-6	20	17.24
6-8	5	4.31
8-10	2	1.73
Above 10	-	-
Total	105	90.52

BIOMASS RAMIFICATIONS

Biomass Availability and Consumption

The only internal energy source of Dhanawas is biomass: that is, cowdung, crop-residue and firewood. The source of obtaining cowdung is mainly the villagers' own livestock; crop-residue is obtained either from own/neighbour's farm or as wages for agricultural labour. Firewood is obtained from the roadside or illegally from a Government plantation close by. In this section, we provide an estimate of the potential availability of cowdung and crop-residue within the village. An estimate of the supply of firewood is beyond the scope of the study, as there is no organized source from where firewood is either collected or purchased and has, therefore, not been attempted.

The availability of cowdung and crop-residue was estimated by a realistic average dung production per animal, and grain and stalk ratio, respectively. For our calculations, we made the following assumptions:

a) Cowdung production per adult-animal= 17 kg of wet dung/day
[1] young-animal=8.5 kg of wet dung/day

b) Straw-grain ratio[1] for i) Mustard = 3.55 : 1
[3] ii) Wheat = 1.48 : 1
iii) Barley = 1.58 : 1

Thus, the formulae used for estimating the supply of

i. cowdung = No. of adult animals x Cowdung production/ Adult animal + No. of young animals x Cowdu production/Young animal

ii. crop residue = (grain produced) x (straw grain ratio)
i

where i = 1, 2, 3

and 1 = mustard
2 = wheat
3 = barley

Consumption figures relate to the actual consumption of biomas fuels as reported by the respondents.

The difference between the supply and consumption ha been termed as **surplus.**

Among the crop-wastes, mustard stalk is most commonl used for direct burning; barley stalks are largely used fo preparing feed for animals. But wheat stalks are exclusivel used for fodder, and stalks are generally left standing in th field itself for animals to graze.

Table 11: Availability And Consumption of Wet Cowdung for Rabi Season According to Land-owned Classification

Unit: quintals

Farmers' category	Supply	Consumption		Dung-cake stored	Surplus
		Dung-cake[1]	Manure[2]		
Big	2639.25	920.35	1240	324.1	154.80
Medium	1947.50	700.05	900	252.15	95.35
Small	1542.75	662.40	500	192.60	187.75
Marginal	1224.00	555.60	520	212.70	-64.30
Landless	1150.75	1045.30	120	178.95	-193.53
All	8504.25	3883.63	3280	1160.60	180.07

Note: Rabi season is considered equivalent to 5 months.

1: For direct burning as a fuel
2: As a soil nutrient

Table 11 indicates that out of 8504.25 quintals of cowdung estimated to be produced in the entire Rabi season in Dhanawas, 180.02 quintals (2.13 per cent) remains unutilized or uncollected. A probable reason for this could be that cattle are taken to the fields for grazing and their dung at this time is wasted. The quantity of dung-cake saved is for winter when the dung-cakes do not dry easily. So, during the summers, extra dung-cakes are dried and stored in a bitola, a hut-like structure made of straw which is, to some extent, waterproof.

The above table indicates that big, medium and small categories of farmers report surplus quantities of dung, while marginal and landless categories report consumption that is higher than production: overall, there is a surplus of dung in the village. This hints at the redistribution of cowdung which, to some extent, does take place among the various farmers' categories. Going by our observations while conducting the survey, a negligible amount of dung is traded for money in the village and most of the surplus quantity of dung is given away freely.

Of the total dung consumed in the village, the percentage share of dung-cake is 54 per cent, and that of manure is 46 per cent, indicating a substantial use of dung for manuring purposes.

Table 12: Availability and Consumption of Crop-residue for Rabi Season According to Land-owned Classification

Unit: quintals

Farmers' category	Supply			Consumption		Surplus	
	Wheat stalks (1)	Mustard stalks (2)	Other stalks (Barley and Chana) (3)	Used as fuel (4)	Used as cattle feed (5)	As fuel [(2)-(4)]	As fodder [(1)+(3)-(5)]
Big	1574.72	1299.30	502.00	306.00	84.31	993.30	1992.41
Medium	565.36	340.80	224.99	150.00	51.93	190.80	738.42
Small	425.06	258.44	37.92	201.75	30.00	56.69	432.98
Marginal	330.63	123.54	49.93	211.50	19.54	-87.96	361.02
Landless	189.44	92.3	102.70	285.45	9.43	-193.15	282.66
All	3085.21	2114.38	917.54	1154.70	195.26	959.68	3807.49

The figures in Table 12 indicate that big and medium farmers are left with large quantities of crop-residue as surplus; to some extent, this surplus gets distributed among the families who are short of this fuel: the landlord gives away a part of it as payment to the agricultural labourers employed in his field. The negative sign against the figures indicating surplus for marginal farmers and landless families illustrates the fact that the consumption in these categories is higher than the production; obviously, even this small quantity is part of the bigger farmer's surplus quantity received as wages.

The above table also indicates that a huge quantity of crop-residue which can be used as cattle-feed, remains unutilized. Only 5 per cent of the total wheat and barley stalks estimated to be produced in the Rabi season was used as fodder. However, our questionnaire was unable to account for the remaining 95% of the crop-residue. It is possible that this huge surplus is ploughed back to the field.

Time and Source of Collection of Biomass Fuels

In Dhanawas, a major portion of the energy consumed is from locally-produced fuels; thus, a substantial amount of time is spent in collecting these fuels. Table 13 indicates that the time spent daily on the collection of cowdung -- including the time spent on making dung-cakes -- and collection of firewood. Since the crop-residue is collected only at the time of harvest, the time spent for its collection has been depicted for the entire Rabi season.

Table 13: Total Time Spent on Collection of Biomass Fuels

Farmers' category	Cowdung (hrs/day)	Firewood (hrs/day)	Crop-residue (hrs/season)
Big	35.00	0.50	2186.00
Medium	21.00	-	912.00
Small	24.50	7.50	956.00
Marginal	22.00	9.00	588.00
Landless	40.00	39.00	1048.50
All	142.50	56.00	5690.50

Table 14 indicates the average time spent on the collection of various biomass fuels and their consumption per family for different farm categories. For comparative purposes, the time spent on collecting crop-residue in hours per day during the Rabi season has been estimated by assuming the duration of the Rabi season to be five months.

Table 14: Average Time Spent on Fuel Collection per Family During Rabi Season

Farmers' category	Cowdung		Firewood		Crop-residue	
	Time spent on collection (hrs/day)	Consumption (10^3 kCal/hh month)	Time spent on collection (hrs/day)	Consumption (10^3 kCal/hh month)	Time spent on collection (hrs/day)	Consumptio (10^3 kCal/ month)
Big	1.94	2153.43	0.03	164.59	0.81	1190.00
Medium	1.62	2212.20	-	-	0.47	807.69
Small	1.17	1239.73	0.36	377.58	0.30	672.50
Marginal	1.05	1134.44	0.43	134.29	0.19	705.00
Landless	0.93	977.36	0.91	604.78	0.16	464.69
All	1.23	1377.41	0.48	342.92	0.33	696.90

The time spent on the collection of cowdung and crop-residue is indicated to have a positive correlation with the size of the land owned which, in turn, has a positive correlation with cattleheads owned for each farmers' category. For firewood, the time spent on collection and land owned[1] has a negative relation, confirming the fact that small farmers having limited quantity of either of the two biomass fuels at their disposal are spending more time in the collection of firewood. The time spent on the collection for a particular fuel is also indicated to have a correlation with its consumption. However, there occur a few anomalies. For instance, a small category of farmers have consumed more firewood than marginal farmers when they spent lesser time in the collection of this fuel. Also, marginal farmers consume more crop residue than small farmers but are observed to spend less time in collection. It should be pointed out that these discrepancies could have been possibly explained or justified if the information on the total quantity collected and purchased was available. Our questionnaire did seek answers to this question but could not obtain satisfactory responses from the villagers. For future surveys, this drawback should be borne in mind.

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[1] see page 18.

Table 15: Sources of Obtaining Cowdung According to Land-owned Classification

Farmers' category	Number of families collecting cowdung	Percentage of total families	No.of families collecting cowdung from	
			Own animals	Other family's animals
Big	18	100.00	18	-
Medium	12	92.31	12	-
Small	20	95.24	20	-
Marginal	19	90.48	19	-
Landless	36	83.72	34	2
All	105	90.52	103	2

Table 16: Sources of Obtaining Crop-Residue According to Land-owned Classification

Farmers' category	No. of families collecting crop-residue	Percentage of total families	No. of families collecting crop-residue from		
			Own farm	Neighbour's farm	Obtained as wages
Big	18	100.00	18	-	-
Medium	12	92.31	10	1	1
Small	19	90.48	13	2	4
Marginal	18	85.71	10	5	3
Landless	24	55.81	2	7	15
All	91	78.45	53	15	23.00

Table 17: Source of Collection of Firewood According to Land-owned Classification

Farmers' category	No. of families collecting firewood	Percentage of total families	No. of families collecting firewood from		
			Roadside	Forest	Own Farms
Big	1	5.56	-	1	-
Medium	-	-	-	-	-
Small	6	28.57	1	3	1
Marginal	3	14.29	1	2	-
Landless	24	55.81	3	21	-
All	34	29.31	5	26	1

Tables 15, 16 and 17 are self-explanatory; they clearly indicate that among the big farmers, crop-residue and cowdung is obtained from each family's own assets of land and animals. With a decrease in the size of the land owned, increasing number of families are either obtaining dung and crop residue from neighbours' farm/cattle or making efforts to obtain firewood from the nearby forest or the roadside.

DOMESTIC SECTOR

Domestic Energy Consumption

The gross monthly domestic energy consumption in Dhanawas works out to 2473.59 x 10^3 kCal per household; Table 18 clearly indicates that it is predominantly a function of the land-resources owned by the family, and correspondingly decreases with the decrease in the size of land owned. The per capita energy consumption level given in Table 19 indicates that the consumption of the big and medium farmers is substantially higher than that of the small and marginal farmers. Probably due to the ready availability of the local fuel i.e. crop-residue, the utilization efficiency of this fuel is considerably lower among the bigger farmers in contrast to their counterparts. It can also be observed that the energy consumption figure for the category of landless labour comes closest to the overall average for the entire village.

Table 18: Monthly Household Energy Consumption Per Family According to Land-owned Classification

Unit: 10^3 kCal

'armers' ate-ory	Total energy consumed per HH (10^3kCal)	Biomass fuels				Non-biomass fuels			Total	
		Dung cake	Firewood		Crop-residue	Coal	Kero-sene	Elect-ricity	Biomass	Non-Biomass
			Logs	Twigs						
ig	3554.81	2153.43	7.92	156.67	1190.00	-	25.17	21.62	3508.02	46.79
		(60.57)	(0.22)	(4.41)	(33.48)	(-)	(0.71)	(0.61)	(98.68)	(1.32)
edium	3107.79	2242.20	-	-	807.69	-	42.73	15.17	3049.99	57.90
		(72.15)	(-)	(-)	(25.99)	(-)	(1.37)	(0.49)	(98.14)	(1.86)
nall	2326.00	1239.73	101.79	275.79	672.50	-	19.13	17.02	2289.81	36.19
		(53.30)	(4.38)	(11.86)	(28.91)	(-)	(0.82)	(0.73)	(98.45)	(1.55)
rginal	2028.52	1134.44	-	134.29	705.00	16.49	22.59	15.39	1973.73	54.46
		(55.93)	(-)	(6.62)	(34.77)	(0.81)	(1.11)	(0.76)	(97.32)	(2.68)
ndless	2117.52	977.36	43.08	561.70	464.69	12.75	38.54	19.40	2046.83	70.69
		(46.16)	(2.03)	(26.53)	(21.94)	(0.60)	(1.82)	(0.92)	(96.66)	(3.34)
l	2473.59	1377.41	35.63	307.29	696.90	7.71	30.54	18.11	2417.23	56.36
		(55.69)	(1.44)	(12.42)	(28.17)	(0.31)	(1.23)	(0.73)	(97.73)	(2.28)

te: Figures in parentheses indicate percentages of the total.

le 19: Per capita Monthly Household Energy Consumption According to Land-owned Classification

Unit: 10^3 kCal

rers' >- /	Total Energy Consumed per capita (10^3 kCal)	Biomass Fuels				Non-Biomass Fuels			Total	
		Dung-cake	Firewood		Crop-residue	Coal	Kerosene	Elect-tricity	Biomass	Non-Biomass
			Logs	Twigs						
	367.74	222.76	0.82	16.21	123.10	-	2.61	2.24	362.89	4.85
		(60.57)	(0.22)	(4.41)	(33.48)	(-)	(0.71)	(0.61)	(98.68)	(1.32)
um	388.47	280.27	-	-	100.96	-	5.34	1.90	381.23	7.24
		(72.15)	(-)	(-)	(25.99)	(-)	(1.37)	(0.49)	(98.14)	(1.86)
l	351.41	187.30	15.38	41.67	101.60	-	2.89	2.57	345.95	5.40
		(53.30)	(4.38)	(11.86)	(28.91)	(-)	(0.82)	(0.73)	(98.45)	(1.55)
inal	289.74	162.06	-	19.18	100.71	2.36	3.23	2.20	281.95	7.79
		(55.94)	(-)	(16.62)	(34.76)	(0.81)	(1.11)	(0.76)	(97.31)	(2.69)
less	338.49	156.23	6.89	89.79	74.28	2.04	6.16	3.10	327.19	11.30
		(46.15)	(2.04)	(26.53)	(21.94)	(0.60)	(1.82)	(0.92)	(96.66)	(3.34)
	344.45	191.83	4.96	42.79	97.03	1.07	4.25	2.52	330.61	7.84
		(55.69)	(1.44)	(12.42)	(28.17)	(0.31)	(1.23)	(0.73)	(97.72)	(2.28)

Figures in parentheses indicate percentages of the total.

In absolute terms, non-biomass fuels constitute 2.28 per cent of the total energy consumed in the domestic sector. Barring the medium farmers' category, the consumption of non-biomass fuels is higher among the marginal farmers and landless. The same trend is noticed as regards the average per capita consumption of non-biomass energy. This can be explained by the fact that marginal farmers with less land and livestock resources at their disposal are forced to buy fuel from the market to meet their needs. The three non-biomass fuels -- coal, kerosene and electricity -- respectively, constitute 0.31, 1.23 and 0.73 per cent of the total household energy consumption. Coal is used mainly for heating purposes, and kerosene and electricity for lighting.

Among the biomass resources, dung-cakes play a predominant role. The extent of use of the various biomass fuels per household is as follows:

dung-cake - 55.69%
crop-residue - 28.17%
firewood: twigs - 12.42%
firewood: logs - 1.44%

This highlights the scanty availability of firewood, owing to which cowdung and crop-residue are used extensively for direct burning, and not as inputs for nourishing the soil; as a result, valuable fertilizer goes up in smoke. The marginal farmer was observed to consume as much of crop-residue as the bigger farmers and this can be justified by the fact that the latter work as agricultural labourers in the bigger farmers' fields and get a share of the produce (mainly wheat) as well as crop-residue (mainly mustard) as payment.

Table 20: Distribution of Households Using Different Fuels According to Land-owned Classificatio

Farmers' category	Biomass fuels								Non-Biomass fuels				
	Cowdung		Firewood				Crop-residue		Kerosene		Electricity		Co
			Logs		Twigs								
	No. of users	% share	No. of users	% share	No. of users	% share	No.of users	% share	No.of users	%share	No.of users	%share	No.of users
Big	18	100.00	1	5.56	1	5.56	18	100.00	15	83.33	11	61.11	0
Medium	12	92.31	0	0.00	0	0.00	12	92.31	11	84.62	8	61.54	0
Small	21	100.00	2	9.52	6	28.57	19	90.48	18	85.71	15	71.43	0
Marginal	19	90.48	0	0.00	2	9.52	20	95.24	17	80.95	8	38.10	2
Landless	34	79.07	3	6.98	24	55.81	23	53.49	38	88.37	21	48.84	2
ALL	104	89.66	6	5.17	33	28.54	92	79.31	99	85.34	63	54.31	4

Table 20 shows the number of families reporting the use of various fuels. Cowdung is the most popular fuel, used by almost 90 per cent of the households. Kerosene and crop-residue is used by 95% and 80% of the households, respectively. Of the three non-biomass sources, coal is used exclusively for heating, electricity for lighting while kerosene is used for both. Biomass resources are consumed for cooking and water-heating, but not for lighting.

The percentage of cowdung and crop-residue use is the least among landless families; however, kerosene and twigs are extensively used.

Table 21 presents the total as well as average energy consumed for the three domestic activities considered, namely cooking, lighting and water-heating. The ranking for these activities, in the order of percentage energy use is cooking (84.51%), water-heating (13.82%) and lighting (1.67%). Cooking, as is to be expected, takes up the major share of the total energy consumed. In the first two farmers' categories, it constitutes about 75 per cent of the total; with the exception of small farmers, the percentage of energy used for this activity is more than 90 per cent for smaller farmers' categories. The first two household categories are observed to consume more energy for water-heating, which can be considered a luxury activity vis-a-vis the other two. The small farmers and landless labourers spare only about 6 per cent of the total energy consumed for water-heating while more than 90 per cent is spent on cooking.

Table 21: Monthly Household Energy Consumption for Various End-uses According to Land-owned Classification

Unit: 10^3 k

rs' ory	Cooking			Lighting			Water-heating			All End uses
	Total	Per HH	Per capita	Total	Per HH	Per capita	Total	Per HH	Per capita	
	49628.54 (77.56)	2757.14	265.22	799.43 (1.25)	44.41	4.59	13557.07 (21.19)	753.17	77.91	63985.04 (100.00
m	30716.03 (76.03)	2362.77	295.35	564.69 (1.40)	43.44	5.43	9120.54 (22.57)	701.58	87.70	40401.26 (100.00
l	44959.49 (92.04)	2140.93	323.45	741.94 (1.52)	35.33	5.34	3143.38 (6.44)	149.60	22.61	48844.81 (100.00
inal	33629.54 (78.96)	1601.41	228.77	771.60 (1.81)	36.74	5.25	8190.62 (19.23)	390.03	55.72	42591.76 (100.00
less	83485.51 (91.69)	1941.52	310.36	1924.7 (2.11)	44.76	7.16	5643.39 (6.20)	131.24	20.90	91053.60 (100.00
	242419.11 (84.51)	2089.82	291.02	4802.36 (1.67)	41.40	5.77	39655.00 (13.82)	341.85	47.61	286876.47 (100.00

Figures in parantheses indicate percentages of the total.
HH = household

Energy for Cooking

The general pattern that emerges from Table 22 is that out of the fuels used in Dhanawas, dung-cake and crop-residue --obtained at a zero cost -- constitute the major energy inputs for cooking. However, the use of these resources among small, marginal and landless categories is slightly restricted; this is due to less availability of crop-residue on account of smaller land-holdings and fewer cattle owned per household. As a result, these households are forced to explore the third biomass resource -- twigs, which too, can be obtained at a zero cost, but require greater effort. Also, the utilization intensity for non-biomass resources is higher in the last two categories; this is because they resort to the use of these fuels to meet a part of their energy needs for cooking, owing to the inadequate supply of the preferred fuels -- crop-residue and dung cake. Interestingly, the share of crop-residue for the marginal farmer is the highest. This is confirmed by the findings of Tables 11 and 12 which show the availability of cow dung and crop-residue to be less than its consumption for marginal farmers and the landless. However, this deviation from the general trend can be accounted for: marginal farmers have easy access to crop-residue as they find employment as agricultural labourers.

Table 22: Monthly Household-Energy Consumption for Cooking According to Land-owned Classification

Unit: Per cent

ers' gory	Biomass fuels				Non-Biomass fuels			TOTAL (10^3 kCal
			Firewood					
	Dung-cake	Crop-residue	Logs	Twigs	Coal	Kerosene	Electricity	
	58.60	38.18	0.29	2.84	-	0.09	-	49628.54
ium	69.65	29.74	-	-	-	0.61	-	30716.03
l	53.02	29.78	4.75	12.41	-	0.04	-	44959.49
ginal	49.30	41.21	-	8.38	1.03	0.08	-	33629.54
less	46.70	22.93	2.05	28.09	0.66	0.54	0.04	83485.51
	53.22	30.71	1.65	13.74	0.37	0.30	0.01	242419.11

The above pattern holds good to some extent even when analyzed on the basis of per household or per capita consumption. (Table 23)

Table 23: Average Monthly Energy Consumption for Cooking According to Land-owned Classification

Unit: 10^3 kCal

ers' gory	Biomass								Non-Biomass					
	Dung-cake		Firewood: logs		Firewood: twigs		Crop-residue		Coal		Kerosene		Electricity	
	Per hh.	Per capita	Per hh.	Per capita	Per hh.	Per capita	Per hh.	Per capita	Per hh.	Per capita	Per hh.	Per capita	Per hh.	Per capita
	1615.6	167.4	7.9	0.9	78.3	8.2	1052.9	109.1	-	-	2.4	0.3	-	-
ium.	1645.5	205.3	-	-	-	-	702.8	88.2	-	-	14.4	1.8	-	-
ll	1133.9	171.3	100.0	15.7	268.6	40.9	637.50	96.5	-	-	0.9	0.1	-	-
inal	789.2	112.2	-	-	134.0	19.7	660.5	94.3	16.5	2.4	1.2	0.2	-	-
less	887.3	141.8	39.9	6.4	546.4	87.4	445.2	71.2	12.8	2.0	10.5	1.7	0.7	0.1
	1112.50	154.9	34.4	4.8	287.2	40.0	642.0	89.4	7.7	1.1	6.2	0.9	0.2	0.03

HH = household

Table 24: Distribution of Households Using Different Fuels for Cooking

Unit: Per cent

Farmers' category	Biomass				Non-Biomass		
	Dung-cake	Firewood		Crop-residue	Kerosene	Electricity	Coal
		Logs	Twigs				
Big	100.00	5.56	5.56	100.00	5.56	-	61.11
Medium	92.31	-	-	92.31	15.38	-	61.54
Small	100.00	9.52	28.57	90.48	4.76	-	71.43
Marginal	25.71	-	9.52	95.24	4.76	-	38.10
Landless	79.07	6.98	55.81	53.49	20.93	4.65	48.84
All	77.79	5.17	28.45	79.31	12.07	1.72	54.31

Table 24 shows the percentage distribution of households reporting the use of various energy sources for cooking. Landless families have reported the maximum use of non-biomass fuels (coal 48.8 per cent; kerosene- 20.9 per cent) and firewood (logs - 55.8 percent; twigs 6.98 per cent). However, no consistent trend can be observed among the various categories.

Energy for Water-heating

Cow-dung and crop-residue were the major fuels for water-heating. The total monthly energy consumed for water-heating in the domestic sector is 39,655 x 10^3 kCal which, on an average works out to be 341.85 x 10^3 kCal per household or 47.61 x 10^3 kCal per capita. Cowdung contributes more than 2/3rd of the total energy consumed for this domestic activity.

Water is heated at a low temperature for preparing animal feed, and bathing and washing clothes, unlike cooking.

For preparing animal feed, cowdung is a very convenient fuel, as it has a low burning rate -- the fodder is allowed to simmer for almost the whole day. Crop-residue is added to accelerate the process of heating. The variation in average energy consumption per household or per capita is too inconsistent among the various categories to arrive at any conclusions. Table 25 indicates the average energy consumption pattern. Table 26 shows the percentage share of various fuels for water-heating.

Table 25: Average Monthly Energy Consumption for Water-heating, According to Land-owned Classification

Unit : 10^3 kCal

Farmers' category	Non-Biomass						Biomass							
	Coal		Kerosene		Electricity		Dung-cake		Firewood: logs		Firewood: twigs		Crop-residue	
	Per hh.	Per capita	Per hh.	Per capita	Per hh.	Per capita	Per hh.	Per capita	Per hh.	Per capita	Per hh.	Per capita	Per hh.	Per capita
Big	-	-	-	-	-	-	538.0	55.6	-	-	79.0	8.0	137.6	14.7
Medium	-	-	-	-	-	-	596.8	74.8	-	-	-	-	105.0	13.7
Small	-	-	-	-	-	-	104.8	16.0	-	-	9.9	1.4	34.7	5.3
Marginal	-	-	-	-	-	-	345.1	49.2	-	-	-	-	45.2	6.3
Landless	-	-	2.0	0.3	-	-	90.1	14.7	3.3	0.6	16.4	2.7	20.0	3.2
All	-	-	0.7	0.001	-	-	265.2	37.1	1.3	0.1	20.0	2.8	54.6	7.4

Note: hh = household

Table 26: Monthly Household Energy Consumption for Water Heating

Unit: Per cent

Farmers' category	Biomass				Non-Biomass			Total (10^3 kCal)
	Dung-cake	Crop-residue	Firewood		Coal	Kerosene	Electricity	
			Logs	Twigs				
Big	71.40	18.20	-	10.40	-	-	-	13557.07
Medium	85.03	14.97	-	-	-	-	-	9120.54
Small	69.89	23.38	-	6.73	-	-	-	3143.38
Marginal	88.46	11.54	-	-	-	-	-	8190.62
Landless	68.58	14.88	2.53	12.49	-	2.32	-	5643.39
All	75.34	16.02	0.86	7.87	-	0.86	-	39655.00

Table 27: Distribution of Households Using Different Fuels for Water Heating

Unit: Per cent

Farmers' category	Biomass				Non-Biomass		
	Dung-Cake	Firewood		Crop-residue	Kerosene	Electricity	Coal
		Logs	Twigs				
Big	77.78	0.0	5.56	44.44	0.0	0.0	0.0
Medium	84.62	0.0	0.0	53.85	0.0	0.0	0.0
Small	28.57	0.0	4.76	19.05	0.0	0.0	0.0
Marginal	47.62	0.0	0.0	28.57	0.0	0.0	0.0
Landless	13.95	2.33	2.33	11.63	4.65	0.0	0.0
All	40.52	0.86	2.59	25.86	1.72	0.0	0.0

Table 27 illustrates the percentage of households using various fuels for water-heating. Cowdung and crop-residue consumption are found to have similar trends: both are higher for medium and small farmers. The share of cowdung and crop-residue in the total energy consumption is the least for landless families. Very few families use kerosene and fuelwood; no family reported the use of electricity and coal for water-heating purposes.

Energy Consumption for Lighting

The total energy consumed for lighting in Dhanawas is 4802.36×10^3 kCal, of which the share of kerosene is 57 per cent; the remaining 43 per cent is contributed by electricity. Barring the category of medium farmers, the percentage share of electricity, to some extent, declines with the size of the land-holding. When analyzed on the basis of per capita consumption (see Table 28), landless families are found to be the highest users of both kerosene and electricity for lighting; the farmer uses this fuel the least. The other categories are almost at par with each other. Consumption for lighting per household is almost the same for the first two categories and for the landless families and smaller farmers, it is substantially lower.

Interestingly, for lighting, the mean energy consumption per household shows only a slight variation (see Table 29); however, the per capita consumption among landless labourers is 50 per cent more than that of the big farmers. Among the land-owning families, there is no significant difference. The reason behind landless households using more energy for lighting is probably that members of this category spend more time at home, unlike farmers; the latter leave for their fields early in the morning, do not return home until after sunset, and retire almost immediately after the evening meal.

Table 28: Average Monthly Energy Consumption for Lighting According to Land-owned Classification

Unit: 10^3 kCal

Farmers' category	Non-Biomass			
	Kerosene		Electricity	
	Per hh.	Per capita	Per hh.	Per capita
Big	22.8	2.4	21.6	2.2
Medium	28.2	3.5	15.2	1.9
Small	18.3	2.7	17.0	2.6
Marginal	21.4	3.1	15.4	2.2
Landless	26.1	4.2	18.7	3.0
All	23.5	3.2	17.9	2.5

Table 29: Monthly Household Energy Consumption for Lighting According to Land-owned Classification

Unit: Per cent

Farmers' category	Non-Biomass		Total (10^3 kCal)
	Kerosene	Electricity	
Big	51.32	48.68	799.43
Medium	65.08	34.92	564.69
Small	51.84	48.16	741.94
Marginal	58.15	41.85	771.70
Landless	58.17	41.83	1924.69
All	56.86	43.14	4802.33

In Table 30, the percentage distribution of the number of users for kerosene and electricity is given for the various categories. It may be observed that the number of houses using electricity is much higher among the first three categories of the farmers.

Table 30: Distribution of Households Using Different Fuels for Lighting According to Land-owned Classification

Unit: Per cent

Farmers' category	Biomass	Non-Biomass	
		Kerosene	Electricity
Big	0.00	77.78	61.11
Medium	0.00	76.92	61.54
Small	0.00	85.71	71.43
Marginal	0.00	76.19	38.10
Landless	0.00	83.72	48.84
All	0.00	81.03	54.31

Dhanavas is an electrified village; even so, only 54 per cent of the houses have power connections. There are two reasons for such low use of electricity: the first is that electricity supply to the village is very erratic; secondly, the initial investment involved in getting an electric connection is very high. Besides, electricity supply has been synchronized to meet agricultural rather than domestic needs; sometimes, when supplied at night-time, the voltage is very low.

AGRICULTURE SECTOR

Energy in Agriculture

For this sector, different farm categories have been defined on the basis of the total land cultivated. In our analysis, we have only taken into account the land cultivated in the Rabi season and not the gross operational area for the whole year. The number of cultivating households in Dhanawas, as estimated in the survey, was 61 (52.6 per cent) of the total number of households. About 46.78 per cent of the cultivating households had an area of more than 5 acres under cultivation, accounting for almost 81 per cent of the total land under cultivation. This disparity was more acute when compared on the basis of the total land owned, where 26.7 per cent of the houses owned 77.66 per cent of the land. (Table 31)

Table 31: Distribution of Household According to Size of Land Cultivated

Farmers' category	Cultivated land (acres)	Number of households	%age of cultivating households	Land under cultivat-ation	%age of total land under cultivation
Big	more than 10	19	30.65	325.00	65.29
Medium	5 - 10	10	16.13	79.00	15.87
Small	2.5 - 5	16	27.42	67.00	13.46
Marginal	Upto 2.5	16	25.80	27.75	5.59
All		61	100.00	497.75	100.00

In this study, a detailed analysis has been carried out for energy inputs for land preparation (this includes tilling, levelling and ploughing) and irrigation, to estimate the energy use and requirements in actual farming conditions (and not under different crop rotations). For land preparation, the level of energy required on tractorized and non-tractorized farms has been estimated and for irrigation, a distinction has been made between farms using electric vis-a-vis diesel pumpsets. The total quantum of energy used for threshing and the quantity of organic and inorganic fertilizer consumed has also been reported, as also the average energy use per acre for the various farmers' categories.

Agricultural Activity - Land Preparation

Tractor use

In this survey, an attempt has been made to find the extent of the use of tractors by various farm categories. Table 32 presents the various parameters that indicate the use pattern of tractors for agricultural purposes in Dhanawas.

Table 32: Tractor Use According to Size of the Land Cultivated

Farmers' category	No. of tractors	HP employed		Machine hour used		Diesel consumption (in l)	
		Total	Per tractor	Total	Per tractor	Total	Per tractor
Big	10	269	26.9	808	80.8	2617	261.7
Medium	4	120	30.0	157	39.25	596	149.0
Small	12	325	27.08	235	19.58	705	58.75
Marginal	16	460	28.75	181.5	11.34	561.75	35.11
All	41	1174	28.63	1381.5	33.70	4469.75	109.02

The above table indicates that bigger farmers use tractor more extensively than smaller farmers. A farmer cultivating a large area uses a tractor for 80.8 hours in th Rabi season and in contrast, the average tractor use is 11.3 hours for marginal farmers. It should be noted that th tractors are not necessarily owned by the user and in fact most of the time they are hired for use.

Table 33 illustrates the percentage of farmers usin mechanized or non-mechanized methods of ploughing, levellin and tilling of land under various farm categories.

Table 33 : Distribution of Households Using Different Methods of Land-Preparation According to Size of the Land Cultivated

Unit: Per cent*

Farmers' category	Tractor farms		Bullock farms		Using both	
	Farms	Area	Farms	Area	Farms	Area
Large	47.37	55.69	47.37	39.38	5.26	4.93
Medium	20.00	19.23	60.00	59.27	20.00	21.50
Small	68.75	65.67	25.00	23.88	6.25	10.45
Marginal	93.75	90.99	0.00	0.00	6.25	9.01
All	59.02	53.29	31.14	38.27	9.84	8.44

Note*: Percentages of the total under each farmers' category.

In Dhanawas, 59.02 per cent of the farmers are using onl tractors for land preparation. Interestingly, the percenta of farmers using tractors in the marginal and small categori is much higher in comparison with the overall average for tl village -- 93.75 and 68.75 per cent, respectively. This is different from what has been reported in earlier studies, where it has been stated that with the increase in farm-size, the mechanization intensity increases [4].

Energy for land preparation

The quantum of energy used varies with the farm categories. Also, a disparity was observed in the type of energy inputs used. In this section, we will discuss the various inputs into the three types of farms, i.e. bullock farms, tractor farms and mixed farms, which have been defined as follows:

Bullock-farms : Farms having bullocks as the source of draught power

Tractor-farms : Farms having tractor as the source of draught power

Mixed-farms : Farms having both tractor and bullocks as the source of draught power

The inputs for this agricultural activity are obtained from three sources -- diesel, bullocks and human. The inputs of these energy sources have been converted into a common energy unit -- kCal; the conversion factors used by us are given below [3].

Source	Conversion Factor
Diesel	8926 kCal/l
Animal Power	2300 kCal/animal-hour
Human Labour	250 kCal/human-hour

The average input of these energy sources into the three farm categories, as reported by the farmers, is shown in Tables 34 and 35. These illustrate the difference between the machine-hours and the animal-pair hours employed on farms using tractors and bullocks. If one assumes that an equal amount of work needs to be done in farms of identical size, irrespective of the inputs used for land-preparation (using tractors or bullocks): it works out that one machine-hour replaces 11.15 animal-pair hours in more than 10 acres of farm land. This substitution factor is a little higher for the medium farmer and much less for the small farmers, being 12.48 and 7.10, respectively. The human labour, in terms of human-hours, is also substantially high for farms using bullocks, in contrast to those using tractors; it increases considerably with the farm size. In respect of farms using bullocks and mixed farms, a marginal difference in utilization of human labour was reported in the big and medium farmers' category. However, among small farmers, human-hours employed per acre were almost three times higher than that of for the corresponding category of farmers using bullocks. In Table 39, the human input for land preparation for the marginal farmer is indicated to be zero. As we have already mentioned, we could include only family labour in our study; and marginal farmers are reported to hire tractors (alongwith the driver) and this explains the zero human input.

Table 34: Average Machine Hours/Animal Pair Hours Used per Acre According to Size of the Land Cultivated

Farmers' category	Tractor farms (Machine hours)	Bullock farms (Animal-pair hours)	Mixed farms	
			Animal-pair hours	Machine hours
Big	4.35	48.52	45	0.25
Medium	5.60	69.89	58.18	1.45
Small	4.93	35.00	160.00	3.43
Marginal	6.79	-	180.00	4.00
All	4.75	52.82	85.30	1.48

Table 35: Average Human Hours Used per Acre According to Size of the Land Cultivated

Farmers' category	Tractor farms	Bullock farms	Mixed farms
Big	15.23	48.52	45.00
Medium	7.87	69.89	58.18
Small	3.82	55.00	160.00
Marginal	4.99	-	180.00
All	11.94	54.28	78.06

Note: The employment on the farm consists of both family labour and hired labour, but in this study we are giving estimates for only the farmer.

Table 36 presents the total quantity of energy used for land preparation by the various farm categories.

Table 36: Average Energy Consumed per Acre for Land Preparation According to Size of the Land Cultivated

Unit: kCal

Farmers' category	Tractor farms	Bullock farms	Mixed farms
Big	149.92	235.32	251.72
Medium	195.54	338.97	329.78
Small	155.69	266.75	860.16
Marginal	216.66	-	980.11
All	159.82	263.83	427.15

A general trend that can be observed from the above table is that farms using tractors are least energy-intensive: farms using bullocks consume, on an average, 1.22 and 2.67 times more energy, respectively, than those using tractors; the consumption in mixed farms is 1.62 times more than in farms using bullocks. The maximum difference in the energy input per acre can be seen among the marginal farmers where a factor difference of more than 4.5 is observed between mixed farms and those using tractors, in contrast to a difference of 1.68 times for the first two farm categories.

Agricultural Activity - Irrigation

Use of pumpsets

In the earlier section, it has been mentioned that more than 82 per cent of the cultivated area during the Rabi season is irrigated in Dhanawas. Pumpsets are the only mode of irrigation as the village has neither a canal or pond of its own nor any water source nearby. In Table 37, we compare the intensity of the use of electric and diesel pumpsets by various farm categories.

Eighty per cent of the pumpsets employed in the village were electrically operated. Similar to the observation made regarding tractor-use, the number of hours a pumpset was used was much higher for the big farmers' category. Also, it was observed that on an average, a diesel pumpset is used more intensively than an electric pumpset. On the other hand, in a farm-category-wise comparison, only the biggest cultivator uses a diesel pumpset for longer hours than an electric pumpset. In the remaining three categories, the number of hours of use was higher for the electric pumpset.

Table 37: Use of Pumpsets According to Size of the Land Cultivated

Farmers' category	No. of Pumpsets		HP employed				Machine-hour				Energy Consumption			
	Electric	Diesel	Total		Per pumpset		Total		Per pumpset		Total		Per pumpset	
			EPS	DPS	EPS	DPS	EPS	DPS	EPS	DPS	EPS	DPS	EPS (KWh)	DPS (l)
Big	23	8	69	59	3.00	7.38	6321	2847	274.83	355.86	19663	4097	855	512
Medium	9	2	36	14	4.00	7.00	2646	475	294.00	237.50	8798	475	978	238
Small	13	4	45	26	3.46	6.50	1466	308	112.77	77.00	4182	452	322	113
Marginal	15	1	47	6	3.13	6.00	958	24	63.87	24.00	3114	24	208	24
All	60	15	196	105	3.27	7.00	11391	3654	189.85	243.60	35757	5048	596	337

Note: EPS = Electric Pumpset
DPS = Diesel Pumpset

More than 60 per cent of the farmers in Dhanawas reported the use of only electric pumpsets (Table 38). Thus, the total area under cultivation by electric pumpsets was 61 per cent. About 13 per cent of the farmers deployed both electric and diesel pumpsets for the irrigational facility. Comparisons across farm categories indicate that more than 30 per cent of the big farmers use both electric and diesel pumpsets. With a decrease in the size of the land, generally, a higher percentage of area was irrigated using electric pumpsets in the four farmers' categories.

Energy for irrigation

A detailed analysis of the irrigation intensity (Table 38) and utilization factor of pumpsets (Table 37), especially electric pumpsets, is given below.

Table 38: Distribution of Households Employing Electric, and Diesel Pumpsets According to Size of the Land Cultivated

Unit: Per cen

Farmers' category	EPS-farms		DPS-farms		EPS+DPS farms		Non-Irrigated fa	
	Farms	Area	Farms	Area	Farms	Area	Farms	Area
Big	52.63	62.71	15.79	26.57	31.58	11.71	-	-
Medium	60.00	57.92	10.00	11.39	10.00	7.59	20.00	23.1
Small	62.50	59.71	18.75	19.40	6.25	7.46	12.50	13.4
Marginal	81.25	80.18	6.25	7.21	-	-	12.50	12.6
All	63.93	61.48	13.11	11.65	13.11	20.89	9.84	6.0

Note : Percentage of the total under each category of farm.

What follows shows that irrigational intensity has almost no correlation with the size of the cultivated land. The key parameters such as machine-hrs/acre or human-hrs/acre are observed to follow a haphazard trend.

Three types of farms are considered for this study.

i. EPS farms - farms using only electric pumpsets

ii. DPS farms - farms using only diesel pumpsets

iii. EPS + DPS farms - farms using both electric and diesel pumpsets

More than two-thirds of the farmers use only electric pumpsets for irrigation. Though the electricity supply is erratic, it is almost assured during the irrigation period. A simple comparison of the fuel cost of running diesel and electric pumpsets can be made on the basis of the actual fuel cost of diesel and electricity in Dhanawas:

i) diesel consumption per acre for DPS = 43.71 l = Rs.76.77 (@Rs.1.65/l)

ii) electricity consumption per acre for EPS= 85.45 kWh = Rs.21.36 (@Rs.0.25/kWh)

The capital investment required for an EPS is less than a DPS. At 1984-85 prices a 5 hp EPS costs Rs.6000 while a DPS of the same capacity costs Rs. 8000 [5]. Thus, in respect of capital and operating cost, an EPS should be more economical than a DPS but still 14.52 per cent of the farmers are using DPS and 12.90 per cent keep them as a stand-by. Power supply being erratic, electric pumpsets are inconvenient.

Table 39: Inputs for Agricultural Activity - Irrigation According to Size of the Land Cultivated

Farmers' Category	Average/acre (EPS)			Average/acre (DPS)			Average/acre (EPS+DPS)				
	Machine hour	Human hour	Elect. (kWh)	Machine hour	Human hour	Diesel (l)	Machine-hour EPS	Machine-hour DPS	Human hour	Elect. (kWh)	Diese (l)
Big	32.42	56.89	86.71	33.89	65.28	48.77	24.19	16.10	54.05	80.11	23.09
Medium	45.23	97.10	150.39	43.18	43.18	43.18	42.67	11.67	54.33	128.00	11.67
Small	29.48	35.78	89.94	25.11	46.00	25.11	40.00	3.60	40.00	120.00	3.60
Marginal	43.06	73.96	139.96	9.60	200.00	9.60	-	-	-	-	-
All	35.12	62.32	110.96	32.26	63.09	43.71	26.02	15.24	53.39	84.79	21.49

Table 40: Average Energy Consumption per Acre for Irrigation According to Size of the Land Cultivated

Unit: (10^3 kCal/acre for Rabi season)

Farmers' category	EPS	DPS	EPS + DPS
Big	88.88	451.64	288.59
Medium	153.76	396.22	227.96
Small	86.38	235.63	145.45
Marginal	139.00	135.69	-
All	111.12	405.93	278.17

The above tables also indicate that the family labour input, on an average, is minimum for an EPS and highest for a DPS.

Although the average machine-hours used per acre for a DPS is marginally less than that for an EPS, however energy consumed per acre was higher for a DPS than an EPS. Also, Table 37 had indicated that the average size of an EPS was much smaller than a DPS, in terms of HP. These arguments indicate either comparative inefficiency of a DPS or under-utilization of an EPS due to unstable electricity supply.

The ranking of the types of farms according to the increasing order of energy intensity in terms of 10^3 kCal/ acre is

1. EPS farm (111.12)
2. EPS + DPS farm (278.17), and
3. DPS farm (405.93).

EPS farms are found to be the least energy-intensive for all categories of farmers except marginal farmers (Table 40). Energy input per acre is five times more than on EPS farms, in big farms using DPS. For other farm categories, the difference factor ranges between 1.2 - 3.2. For EPS, the average energy input per acre keeps fluctuating, but declines consistently with the decrease in land-holding size for diesel-using farms. For EPS farms, both human and electric energy inputs increase or decrease together (Table 39), indicating a correlation between the two. The same trend is not so consistent for farms using electric and/or diesel energy.

Agricultural Activity - Threshing

Use of threshers

In Table 41, we present key parameters indicating the pattern of use of threshers by various farm categories.

It can be observed from Table 41 that almost all the farmers use electric threshers, barring one among the big and small categories, respectively. It has been mentioned earlier that for this activity, electricity supply is more or less assured from the main grid. Except for major constraints, electric threshers are preferred by the farmers to diesel ones.

Table 41: Use of Threshers According to Size of the Land Cultivated

Farmers' category	Number of threshers		HP employed		Machine-Hr used		Energy consumption			
							Electricity (kWh)		Diesel (l)	
	Electric	Diesel	Total	Per thresher	Total	Per thresher	Total	Per thresher	Total	Per thresh
Big	18	1	280	14.74	762	40.11	4155	230.8	30	30
Medium	10	-	147.50	14.75	100	10.00	1470	147.0	-	-
Small	15	1	217.50	13.59	162	10.80	1028	68.5	30	30
Marginal	16	-	225.00	14.06	71	4.44	462	28.9	-	-
All	59	2	870.00	14.26	1155	18.93	7115	100.6	60	30

On an average, the number of hours that a thresher is used is substantially higher in the big farmers' category in comparison to the smaller farmers.

Energy for threshing

Threshing is required only for the wheat crop in the Rabi season. It has been reported that farmers are using mechanized methods for threshing their wheat produce. In this section, we discuss in detail the energy consumed for this post- harvest agricultural activity. The energy consumption norms for threshing have been evolved from the primary data in terms of energy consumed per kg of wheat grain.

Table 42 indicates the average electricity and diesel consumption per kg of grain, which varies from 0.029 to 0.0448 kWh for electricity and 0.0075 to 0.0188 l for diesel.

Table 42: Energy Input for Threshing According to Land Cultivated Classification

Farmers' category	Total energy consumed		Average energy used per kg of wheat grain	
	Electricity (kWh)	Diesel (l)	Electricity (kWh)	Diesel (l)
Big	4155	30	0.033	0.0075
Medium	1470	-	0.0448	-
Small	1028	30	0.0376	0.0188
Marginal	412	-	0.0290	-
All	7115	60	0.0341	0.0107

Fertilizers

The total fertilizer consumption in the Rabi season, as estimated by us, was 3938.50 quintals. Out of this total, 3,780 quintals (96 per cent) was organic and the remaining 158.5 quintals (4 per cent) was inorganic. Table 43 shows the average organic (cowdung and crop-residue) and inorganic (urea and phosphate) fertilizer application for various farmer's categories.

Table 43 indicates that the average application of urea and phosphate per acre in the village was 0.27 and 0.21 quintals, respectively. Corresponding figures for cowdung and crop-residue were 9.12 and 4.35 quintals, respectively. This clearly indicates that by far the major source of soil nutrients in Dhanavas is organic manure. This table also depicts another interesting fact: with the decrease in the size of the land cultivated, the average application of inorganic fertilizers increases. A comparison across farmers' categories, of the average application of cowdung manure, indicates a negative correlation with the size of the farm. However, it should be noted that to a great extent, crop-residue manure compensates for low cowdung use per acre in big farmers' fields. In fact, only this category of farmers reported the use of crop-residue as manure.

Table 43: Energy Consumption For The Agricultural Activity – Application Of Fertilizer According to Size of the Land Cultivated

Farmers' category	Total area using urea	Total urea application	Average urea application per acre	Total area using phosphate	Total phosphate application	Average phosphate per acre	Total area using CD as manure	Total CD application	Average CD per acre	Total area using CR as manure	Total CR application	Average CR application
	(acres)	(quintals)	(quintals/	(acres)	(quintals)							
	(quintals)	(acres)	(quintals/ acre	(quintals/	(quintals)	(quintals) acre	(quintals/	acre	acre			acre
Big	310.00	70.5	0.230	113	19	0.17	244.00	1320	7.46	115.00	500	4.35
Medium	60.00	22.00	0.370	22.5	4.5	0.20	68.00	720	10.59	–	–	–
Small	56.00	18.50	0.330	23	5.5	0.24	34.00	360	10.59	–	–	–
Marginal	24.49	11.75	0.480	9	2.75	0.31	13.49	380	28.17	–	–	–
All	450.49	122.75	0.27	167.5	35.75	0.21	359.49	3200	9.12	115.00	500	4.35

Note: CD = cowdung, CR = crop-residue.

Table 44: Normative Data for Pumpsets, Tractors and Threshers

Description	Unit	TERI's estimate	NCAER estimate
A. Diesel Pumpset			
a. Average capacity	hp	7	5
b. Diesel consumption rate	1/hp/acre	6.65	6.84
c. Average use for Rabi	hours/pumpset	244	NA
B. Electric Pumpset			
a. Average capacity	hp	3	5
b. Electricity consumption rate	kWh/hp/acre	35.79	28.00
c. Average use for Rabi	hours/pumpset	190.00	NA
C. Tractor for Agricultural use			
a. Average capacity	hp	30	NA
b. Diesel consumption rate	1/hp/acre	0.63	0.275
c. Average use for Rabi	hours	34	NA
D. Electric Thresher			
a. Average capacity	hp	14	NA
b. Electricity consumption rate	kWh/kg of grain	0.0341	0.0338
c. Average use for Rabi	hours	19	NA

Normative Data for Pumpsets, Tractors and Threshers

In this section, a summarized view of the energy consumption pattern for different agricultural operations is provided. Basically, a presentation of technical norms of fuel consumption for each operation is made on the basis of the data analyzed earlier. Along with this, we have compared our estimated norms with those of the National Council of Applied Economic Research (NCAER) in their report on Rural Energy Consumption in Northern India (1979). The data tabulated also estimated the precise extent of use of machines in Dhanawas.

Interestingly, TERI's and NCAER's estimates were observed to be almost identical for irrigation and threshing operations. However, the diesel consumption rate for tractors, as estimated by TERI, was much higher than NCAER's estimate.

Also, by TERI's estimate, the average use that a diesel pumpset is put to in the Rabi season, was higher by 28 per cent, than an electric pumpset.

EFFECTS OF MECHANIZATION ON CROP PRODUCTIVITY

Indian agriculture in the past few decades has witnessed a gradual increase in the substitution of conventional draught power by mechanical devices. In Punjab and Haryana in particular, the level of machine use (such as tractors, pumpsets, threshers, etc.) has taken place at a relatively faster rate.

The debate on the benefits of mechanization of agriculture in labour-surplus countries like India is inconclusive. Empirical studies [4] indicate that mechanization has a positive influence over the crop-yield and a negative one over labour requirement. Nevertheless, the sale of tractors has been increasing steadily in India.

In this section, we have attempted to compare the yields of the two main crops in Dhanawas: those grown on tractorized and irrigated fields vis-a-vis those grown on non-tractorized and non-irrigated land. The objective is to provide convincing

Unit: Area in acres
Yield: quintals/acre

amers' ate- ory	Area irrigated				Area, tractorized, [Irrigated]				Non-tractorized [Irrigated] '				Area, non-Irrigated				Tractorized [Non-irrigated]				Non-tractorized [Non-irrigated]			
	Local		HYV		Local		HYV		Local		HYV		Local		HYV		Local		HYV		Local		HYV	
	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield
g	38	4.32	44	4.82	31	4.64	13	4.77	7	2.86	31	4.84	–	–	10	2.4	–	–	10	2.4	–	–	–	–
dium	2	4.00	23	4.61	2	4.00	7	8.00	–	–	16	3.12	–	–	–	–	–	–	–	–	–	–	–	–
all	3	4.67	7.5	4.59	–	–	6.5	4.43	3	4.27	1	5.60	–	–	1	2.0	–	–	1	2.0	–	–	–	–
rginal	–	–	6.0	3.80	–	–	4	3.70	–	–	2	4.0	–	–	–	–	–	–	–	–	–	–	–	–
l	43	4.33	80.05	4.66	33	4.60	30.5	5.30	10	3.00	50	4.27	–	–	11	2.36	–	–	11	2.36	–	–	–	–

e: This Table probably does not account for the entire area irrigated under mustard crop as a few questionnaire did not provide complete information and thus had to be discarded.

evidence of the effect of mechanization on the output. The multiple regression technique has been applied to obtain the total crop production as a function of area irrigated, tractorized and under HYV (High Yielding Variety).

In Tables 45 and 46, comparisons have been made for mustard and wheat crop grown on land categorized as follows:

i. Irrigated
ii. Non-irrigated
iii. Tractorized
iv. Non-tractorized

The use of traditional seeds or HYV has also been taken into account.

Table 46: Wheat Crop Yield on Various Land Categories and According to Size of the Land Cultivated

Unit: Area in acres
Yield: in quintals/acre

rmers' tegory	Area irrigated				Area tractorized, [Irrigated]				Non-tractorized [Irrigated]			
	Local		HYV		Local		HYV		Local		HYV	
	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield
ig	43	8.32	108	8.44	29	8.62	62	8.76	14	7.72	46	8.35
dium	3	6.67	36	8.56	3	6.67	15	9.33	-	-	21	8.00
all	7	5.14	42.5	6.62	7	5.14	34.5	6.91	-	-	8	6.25
rginal	3.38	7.04	18.13	7.12	3.38	7.04	16.13	6.86	-	-	2	4.00
l	56.38	7.76	204.63	7.97	42.38	7.79	127.63	7.98	14	7.72	77	7.92

te: No non-irrigated area under wheat was reported.

This Table probably does not account for the entire area irrigated under wheat crop as a few questionnaires did not provide complete information and thus had to be discarded.

The average yields for both the crops.- wheat and mustard were observed to be the highest on farms that are irrigated, tractorized and use HYV. The last has resulted in higher yields for both the crops on mechanized as well as non-mechanized farms. Presented below is a summary of Tables 45 and 46.

Yield: quintals/acre

			Crop-Yield	
			Mustard	Wheat
1.	Non-Irrigated	Local	-	-
		HYV	2.36	-
2.	Irrigated	Local	4.33	7.76
		HYV	4.66	7.97
3.	Non-tractorized and Irrigated	Local	3.00	7.72
		HYV	4.27	7.92
4.	Tractorized and Non-Irrigated	Local	-	-
		HYV	2.36	-
5.	Tractorized and Irrigated	Local	4.60	7.78
		HYV	5.30	7.98

On comparing the impact of irrigation on yields, it was observed that one acre of non-irrigated land using HYV, yields 2.36 quintals of mustard crop; the corresponding figure on irrigated land is 4.66, a difference of 97 per cent which is substantial. A similar comparison was not possible for the wheat crop, as wheat is not grown on non-irrigated land in Dhanawas. On the other hand, while tractorization does have a positive influence on the yield, the difference of yield on tractorized and non-tractorized farms was relatively small, especially for the wheat crop. For example, our findings indicate that the average mustard yield on irrigated non-tractorized farms using HYV is 4.27 quintals per acre; for wheat, it is 7.92 quintals/acre. The corresponding figures for these crops on non-tractorized land were 5.30 and 7.98, respectively, i.e. 24 per cent and 0.8 per cent higher. However, it should also be mentioned that across the farmers' categories, another trend that is observed is that barring a few exceptions, crop yields for wheat and mustard increase with the increase in the size of the area cultivated.

To sum up, the factors found to influence crop yields are:

i. size of the land cultivated
ii. irrigation
iii. use of HYV
iv) tractorization

However, since in this village, no case of a farmer using HYV on non-irrigated and non-tractorized farm was found, it was not possible to indicate the variation in crop yield vis-a-vis the use of HYV and no mechanization. Empirical studies have indicated that crop-yield falls considerably if the farm is non-irrigated but uses HYV. In some cases, it has been found to be less than the yield a farmer would obtain using traditional/local variety of seeds on non-irrigated farm.

Regression Analysis

To support and confirm the above findings, a uni-variate regression technique was applied to obtain the total crop production as a function of types of land cultivated.

In the regression analysis used by us, the endogenous variable has been taken as the total crop production i) for wheat and ii) for mustard per household; the exogenous variables included were:

i. area irrigated
ii. area tractorized
iii. area irrigated and using HYV
iv. area irrigated and tractorized, and
v. area irrigated, tractorized and using HYV.

Tables 47 summarizes the results of the regression analysis. These indicate that the five variables considered explanatory power in predicting the crop-production level in the village.

Table 47: Results of Uni-variable Regression Analysis

ndent Variables	Constant	Co-efficient Matrix					
		Area irrigated (acres/HH)	Area tractorized (acres/HH)	Area irrigated and under HYV (acres/HH)	Area irrigated and trac-torized (acres/HH)	Area irrigated tractorized and under HYV	R^2
p: Mustard							
g.Production (per HH)	6.1075	9.9643 (9.827)					72.29
"	2.1219		10.0679 (11.870)				87.03
"	6.3940			9.9361 (9.303)			71.79
"	8.2774				9.8700 (7.822)		77.27
	8.7983					9.8579 (7.597)	77.25
p: Wheat							
g.Production (per HH)	-0.53810	19.8609 (15.190)					81.70
	-0.11922		19.3583 (13.967)				0.8170
"	-0.3381			19.6237 (12.594)			79.86
"	-0.1077				19.3567 (13.020)		81.70
"	-0.4973					19.7615 (11.279)	82.49

= agricultural
= household

: Figures in parentheses indicate the t-value of the corresponding explanatory variables.

The above Table indicates that over a period of two years the average family size has increased from 7.0 to 7.18 while the per capita cattle ownership has declined from 0.51 to 0.49.

Reduction in per-capita cattle ownership in turn, reduces the availability of dung per person/household. This declined from 8.68 and 60.78 kg in the year 1984 to 8.29 and 59.50 kg, respectively in 1986. Average availability of wheat-stalks was also observed to have declined by 10 per cent in Dhanawas. This is due to the fact that the percentage land area under wheat has come down from 58.3 per cent in 1984 to 52.6 in 1986 (see Table 50). With similar reason, but in reverse trend, mustard-stock availability per person almost doubled between 1984 and '86, increasing from 125.78 kg in 1984 to 253.83 kg in 1986. We would like to again point out that while wheat-stalks are used as fodder, mustard-stalks are used exclusively as fuel. Thus, enhanced supply of mustard stalks implies greater availability of fuel to the villagers.

Average per capita monthly energy consumption in the domestic sector was estimated to increase from 283.57 10^3 kCal in 1984 to 344.45 10^3 kCal in 1986, that is about 21.5 per cent higher than in 1984. Per household energy consumption was indicated to have gone up by 24.32 per cent in 1986 than in 1984. A comparison in terms of energy consumed by end-use indicates that over these two years, the share of cooking energy in the total domestic energy consumption has increased by 6.01 per cent, while the share of water-heating and lighting have declined by 2253 and 31.56 per cent, respectively.

CHANGES IN ENERGY CONSUMPTION PATTERN IN DHANAWAS

This chapter gives an overview of the estimated changes in the pattern of energy consumption in the domestic and agricultural sectors in Dhanawas. The analysis is based on the available data from the two census surveys conducted by TERI [5]. And the results of the survey in 1986 are presented in the previous sections.

It should be noted while making comparisons between the findings of 1984 and 1986 village surveys that both these studies are almost identical in respect of coverage of fuels, end-uses and unit of aggregation of different energy sources. Also, data is comparable as there is no variation in the methodology of the two surveys. However, the recent survey - especially with respect to the agriculture sector - was more extensive.

Pattern of Household Energy Consumption

Table 48 gives estimates of energy consumption and supply in Dhanawas for the years 1984 and 1986 and some socio-economic factors influencing energy consumption in households.

Table 48: Trends in Domestic Energy Consumption Pattern in Dhanawas

Particulars	Unit	1984	1986	%age chang (1984-86)
I. Socio-economic				
1.average family size	numbers	7.0	7.18	2.57
2.per capita cattle population	numbers	0.51	0.49	-3.92
II.Energy-supply				
1.Dung available				
a.Per capita	kg/day	8.68	8.29	-4.49
b.Per household	kg/day	60.78	59.50	-2.11
2.Crop-residue available				
i.Wheat				
a.Per capita	kg(Rabi-season)	412.77	370.37	-10.27
b.Per household	kg(Rabi-season)	2889.45	2659.66	-7.95
ii.Mustard				
a.Per capita	kg(Rabi-season)	125.78	253.83	+101.80
b.Per household	kg(Rabi-season)	880.40	1848.60	+109.97
III.Energy consumption in the Households				
Per capita	10^3 kCal/month	283.57	344.45	+21.47
Per household	10^3 kCal/month	1989.74	2473.59	+24.32
ii. Share of different domestic activities				
a.cooking	Per cent	79.72	84.51	6.01
b.Water heating	Per cent	17.84	13.82	-22.53
c.lighting	Per cent	2.44	1.67	-31.56
iii.Share of different fuels				
a.Coal/coke	Per cent	1.53	0.31	-79.74
b.Electricity	Per cent	0.62	0.73	+17.74
c.Kerosene	Per cent	2.17	1.23	-43.32
d.Crop-residue	Per cent	41.16	28.17	-31.56
e.Cowdung	Per cent	51.40	55.69	+8.35
f.Firewood	Per cent	3.11	13.86	+345.66
g.Total				
i.Non-biomass	Per cent	4.32	2.27	-47.35
ii.Biomass	Per cent	95.68	97.72	+2.73

If we look at the fuel composition of energy, we find that the dependence of the villagers on biomass fuels in Dhanawas has increased by 2.3 per cent in the past two years. Among the various biomass fuels, the percentage share of firewood has increased from 3.11 in 1984 to 13.86 in 1986, which is a tremendous jump. While crop-residue availability is estimated to double in these two years, its contribution in the overall energy consumption pattern declined by 31.56 per cent; the reverse is found true for cowdung. Among non-biomass fuels, the contribution of coal and kerosene has declined and electricity's contribution has increased by 17.74 per cent.

The Coefficient of Variance (C.V.) with respect to the mean of consumption of four biomass fuels ranges between 69.77-666.67 per cent. For non-biomass fuels, C.V. is still higher (Ref. Appendix I). This indicates that the variability of actual observations with respect to the mean is very high and that this mean does not truely represent the 'central tendency' of the data-set. In Appendix I we have presented Tables of average fuel consumption with calculated standard deviations. Coefficient of Variance is calculated by dividing standard deviations with the mean of the data-set. We would like to point out that such high disparity among the data points is quite possible in Dhanawas, where the availability of fuel is not perceived as a problem and there are various fuels to choose from. Also, the collection efficiencies for cowdung and crop-residues with higher availability in big farms and landless and marginal farmers are allowed to collect the surplus quantity. This, reflects the fact that variation in the consumption pattern is inherent in the system and is not necessarily due to unreliable data.

Pattern of Agricultural Energy Consumption

Table 49 summarizes the findings of the two surveys related to the agricultural sector. The parameters included,

Table 49: Trends in Domestic Energy Consumption Pattern in Dhanawas

Particulars	Unit	1984	1986	%age change 1984-86
I. General				
a. Per capita land-holding size	acre	0.74	0.68	-8.11
b. Per capita land cultivated	acre	0.61	0.59	-3.82
c. %age of land irrigated w.r.t total cultivated	per cent	94.74	94.02	neg.
d. Share of area under				
i. Wheat	per cent	50.28	52.59	-9.76
ii. Mustard	per cent	19.20	27.22	+41.77
iii. Barley	per cent	13.35	17.78	+33.18
e. Average yield of				
i. Wheat	quintal/acre	7.84	7.97	+1.66
ii. Mustard	quintal/acre	3.02	4.40	+45.70
iii. Barley	quintal/acre	6.05	6.43	+6.28
II. Energy Consumption in Agriculture				
a. Average energy consumption for				
i. Irrigation	10^3 kCal/acre	472.46	113.21(E)[2]	-76.04
ii. Land preparation	10^3 kCal/acre	170.58	221.97	+30.13
iii. Threshing	10^3 kCal/quintal of wheat grain	2.99	2.94	-1.67
b. Share of electricity in				
i. Irrigation	Per cent	51.66	68.14	+31.90
ii. Threshing	Per cent	81.53	91.51	+12.24
c. Fertilizer application				
a. Organic	quintal/acre	12.75	9.12	-28.47
b. Inorganic	quintal/acre	0.40	0.48	+20.00
c. Total	quintal/acre	13.15	9.60	-26.97

Notes 1: Irrigation Using Diesel Pumpsets
2: Irrigation Using Electric Pumpsets

provide an indication regarding the changes in land utilization and energy consumption patterns that have taken place in the past two years.

The table indicates that on an average, land owned by a villager has declined by 8.11 per cent since 1984. Consequently, per capita land cultivated also shows a declining trend. However, it should be noted that while 82-83 per cent of the land owned is reported to have been cultivated in 1984, the corresponding percentage is 86.8 in 1986 -- an indication of the higher utilization of land in Rabi cultivation. The percentage of land irrigated to the total cultivated has remained the same at 95 per cent.

A comparison of the cropping pattern indicates a higher percentage of area grown under mustard and barley in 1986 than in 1984. The share of area under mustard w.r.t. to the total land cultivated has increased from 19.2 to 27.22 per cent and that under barley from 13.35 to 17.78 per cent. The shift has occurred mainly from the area previously cropped under wheat, which indicates a reduction of 9.76 per cent in its share of the total cropped area between 1984-86.

The average yield of these three main crops is reported to be higher in 1986 than the corresponding yields obtained in 1984. Mustard crop in particular, indicates a growth of 45.70 per cent in 1986 over its average yield in 1984.

Energy consumption in the agriculture sector has been estimated for three activities in both the surveys, viz.

irrigation, land preparation and threshing. The average energy consumption for irrigating one acre has been estimated to decline tremendously in 1986. In 1984, 472.46 x 10^3 kCal of energy is estimated to have been consumed on an average for irrigating one acre in 1986. The corresponding figure for 1986 is 113.21 x 10^3 kCal (if the electric pumpset was used) or 274.26 x 10^3 kCal (if diesel pumpset has been used). This result is not surprising, considering the fact that the 1984 survey was carried out in the month of March i.e. pre-monsoon and the second in the month of September i.e. post-monsoon. For land preparation (which includes tilling, levelling and ploughing) energy consumed shows an increases from 170.58 x 10^3 kCal in 1984 to 221.97 x 10^3 kCal in '86, an increase of 30 per cent. Average energy consumed for threshing one quintal of wheat-grain shows a marginal difference over the two years.

Of the total commercial energy consumed (i.e. diesel and electricity) for irrigation, the share of electricity is observed to have increased from 51.66 per cent in 1984 to 68.14 per cent in 1986. For threshing also, a higher contribution from electricity is reported.

A comparison of the fertilizer application in the two indicates that while organic manure is the major source of providing nutrients to the soil in both the years viz. 1984 and 1986, its application per acre has been estimated to come down from 12.75 quintals in 1984 to 9.12 quintals in 1986. On the other hand, the average application of inorganic fertilizers has been reported to increase from 0.4 quintals in 1984 to 0.48 quintals in 1986.

MAIN FINDINGS

In carrying out the above exercise, the overriding objective has been to highlight the needs and priorities of village Dhanawas, that should constitute the basis for rural energy planning. Due effort has also been made to determine an assured supply of energy to help plan for appropriate energy investments and capacity.

From the preceding discussions, the salient features of the village Dhanawas that emerge are as follows:

1. The distribution of households according to the size of land owned was

    (i) Big farmers (possessing more than 10 acres of land) - 15.52%

    (ii) Medium farmers (possessing land in the range of 5-10 acres) - 11.21%

    (iii) Small farmers (possessing land in the range of 5-10 acres) - 18.10%

    (iv) Marginal farmers (possessing land in the range of 5-10 acres) - 18.10%

    vi) Landless - 37.07%

2. The distribution of households according to the size of land cultivated -

    (i) Big 16.38%

    (ii) Medium 8.62%

    (iii) Small 14.66%

    (iv) Marginal 13.79%

    (v) Non-cultivating 46.55%

3. The average family-size in the village is reported to be 7.18 and is observed to increase with an increase in size of land owned.

4. Per capita cultivable land is 0.68 acres; per capita gross cultivated land in Rabi Season is 0.60 acres, that is, 88 per cent of the cultivable land. Further, it has been that 95 per cent of the total land cultivated is irrigated using pumpsets.

5. A study of the cropping pattern reveals that wheat, mustard and barley are the major crops of the Rabi season. The area covered under these three crops is 52.59 per cent, 27.22 per cent and 17.78 per cent, respectively.

6. The average yields of wheat, mustard and barley obtained in the village are 7.97, 4.40 and 6.43 quintals/acre, respectively.

7. Out of a total of 116 households surveyed 105 (90.52%) have reported the possession of cattlehead(s). The total cattle population is 406 with an average of 3.5 cattleheads per household. The distribution of cattleheads with regard to adults and calves is 64.3 and 35.8 per cent, respectively.

8. It was observed that composition of fuels for domestic use was not significantly affected by the size of the land owned by a family.

9. The total production of cowdung in the Rabi season is estimated to be 8504.25 quintals. The distribution of

cowdung for various uses is 3883.63 quintals for consumption as fuel; 3280 quintals as manure and 1160.60 quintals stored for rainy and winter seasons. 180.07 quintals of the dung produced remains uncollected or unutilized.

10. The estimated production of crop-residue from wheat, mustard and barley stalks is 3085.21, 2114.38 and 1283.63 quintals, respectively. The total consumption of crop-residue as fuel is estimated to be 1154.7 quintals and 195.26 quintals as fodder. The rest remains unaccounted for and we have termed it as surplus.

11. On an average, tractor farms were found to be the least energy-intensive and mixed farms the highest.

12. For irrigation, energy input for an electric pumpset was observed to be almost 4 times less than a diesel pumpset per acre, though the number of hours of operations and human hours per acre are almost the same for electric and diesel pumpsets.

A brief resume of the findings related to the energy consumption pattern of the village and those features that are essential for the design of the work-plan are, outlined below.

The energy-related activities and the various inputs used in Dhanawas are given in the following table.

Table 50: Listing of Activities and Energy Sources Considered in the Study

Activity	Energy Source
I. Domestic	
a) Cooking	a. Cowdung
	b. Crop-residue
b) Water heating	c. Firewood
	d. Coal/coke:
c) Lighting	e. Electricity
	f. Kerosene
II. Agriculture	
a) Pumping	a. Electricity
b) Traction	b. Diesel
c) Threshing	c. Inorganic fertilizer
d) Fertilizer	d. Organic fertilizer

A matrix depicting the aggregated resource utilization for the various activities is given in Table 51. All the energy input figures have been converted into one unit (10^6 kCal) so that the relative contributions of the various sources can be obtained. (see Table 52)

The extent of the use of various sources is as follows:-

cowdung	49.00 per cent
crop-residue	24.80 per cent
twigs	10.93 per cent
diesel	3.25 per cent
bullock power	3.03 per cent
electricity	2.91 per cent
logs	1.27 per cent
human power	0.64 per cent
coal/coke	0.28 per cent

Table 51: Dhanawas Energy Source - Activity Matrix for Rabi Season

Unit: 10^6 kCal

e/ ity	Cooking	Water-heating	Lighting	Irrigation	Mobile power for land preparation	Threshing	Total	Fertilizer/ Manure (quintals)
ng	645.2	153.7	-	-	-	-	798.00	-
residue	372.4	31.8	-	-	-	-	404.7	-
ood: logs	20.0	0.7	-	-	-	-	20.7	-
twigs	166.6	11.6	-	-	-	-	178.2	
sene	3.6	0.4	13.7	-	-	-	17.7	-
tricity	0.1	-	10.4	30.8	-	6.1	47.4	-
/Coke	4.5	-	-	-	-	-	4.5	-
el	-	-	-	45.1	39.9	0.5	85.5	-
ock Power	-	-	-	-	62.5	-	62.5	-
Labour	-	-	-	6.2	4.2	-	10.4	-
l	1212.4	198.2	24.1	82.1	106.6	6.6	1630.0	-
ic Fer-ilizer (quintal)	-	-	-	-	-	-		3395.0
ganic Fer-ilizer (quintal)	-	-	-	-	-	-		290.3
l								3685.3

Table 52: Dhanawas Energy Source - Activity Matrix

Unit: Per

Source/ Activity	Cooking	Water-heating	Lighting	Irriga- tion	Mobile Power for land preparation	Threshing	Tota
Cowdung	80.76 (53.22)	19.24 (77.56)	-	-	-	-	100. (49.
Crop residue	92.13 (30.72)	7.87 (16.04)	-	-	-	-	100. (24
Firewood: logs	96.62 (1.65)	3.38 (0.35)	-	-	-	-	100. (1.
twigs	93.49 (13.74)	6.51 (5.85)	-	-	-	-	100. (10.
Kerosene	20.34 (0.29)	2.20 (0.20)	77.40 (56.85)	-	-	-	100. (1.
Electricity	0.21 (0.01)	-	21.94 (43.15)	64.98 (37.52)	-	12.87 (92.42)	100. (2.
Coal/coke	100.00 (0.37)	-	-	-	-	-	100. (0.2
Diesel	-	-	-	52.75 (54.93)	46.67 (37.43)	0.58 (7.58)	100. (5.
Bullock Power	-	-	-	-	100.00 (56.63)	-	100. (0.
Human Labour	-	-	-	59.62 (7.55)	40.38 (3.94)	-	100. (0.
Total	74.38 (100.00)	12.12 (100.00)	1.48 (100.00)	5.04 (100.00)	6.54 (100.00)	0.40 (100.00)	100. (100.

Note: Figures in parentheses are the percentages of the Column - Total (Activity-wi
figures without parentheses are the percentages of the Row - Total (Fuel-wise).

The ranking for the various activities (in the order of percentage use) is ;

cooking	74.38 per cent
water-heating	12.16 per cent
mobile power for land preparation	6.54 per cent
pumping	5.04 per cent
lighting	1.48 per cent
threshing	0.40 per cent

A uni-variate regressional analysis approach has been adopted to identify the possible relationships that exist between the key energy and non-energy parameters. This was attempted in order to predict the changes -- increase or decrease -- in total domestic energy consumption that are likely to follow as a result of variation in two energy-yielding, non-energy sources, that is, land and cattle. The results of this regression analysis have not been presented in the earlier chapters as they were not found to be statistically significant. However, we feel that these findings are not meaningless; they are summarized in Table 53.

A prominent feature of the regression results presented above is that the R^2 for all eight attempted regressions for most of the variables were too low and t-values to be significant. R^2 values indicate the degree of variation explained by the exogenous variable on to the endogenous variable; t-value provides the level of significance of the coefficient attached to an explanatory variable. Thus, the results of the regression analysis indicate that while the exogenous variables are highly significant (barring regressions

Table 53: Coefficient Matrix, with Energy Parameters as Endogenous Variables and non-Energy Parameters as Exogenous Variables

Unit: Per cent

Endogenous variable	Constant	Exogenous variables			R²	Confidence limit of t-value
		Land owned	Land cultivated	Cattle population		
Dung cake produced	7.6641			0.9633 (5.124)	0.2030	99.5%
Dung cake consumed	6.0778			0.5722 (4.890)	0.1883	99.5%
Crop residue consumed	5.066	0.1928 (2.308)			0.0698	99.5%
Crop residue consumed	5.8996		0.2012 (2.028)		0.0652	95.5%
FW-logs consumed	0.2555		-0.012 (0.453)		0.004	60%
FW-twigs consumed	1.0345		-0.0504 (1.085)		0.0190	80%
FW-logs consumed	0.2874		-0.009 (0.405)		0.0023	60%
FW-twigs consumed	1.1861		-0.029 (0.599)		0.0050	70%

Note: FW = firewood

Figures in parentheses are t-values.

5,6,7 and 8, they are apparently not very useful in predicting the consumption level of cowdung and crop-residue in the village. The probable reason for this could be that Dhanawas does not have an 'energy-problem'. The supply of cowdung and crop-residue is estimated to be in excess of their consumption. It has been indicated that in the Rabi season, surplus cowdung and crop-residue (for fuel) is 18 tonnes and 96 tonnes, respectively. Small farmers and landless labourers are allowed to collect the crop-wastes from the fields of the bigger farmers. In short, there is not much pressure on fuel resources and access to cowdung and crop-residue is not heavily influenced by animal and land ownership patterns. Hence, a set of exogenous variables that would explain the variation in the use of biomass fuels in this village needs to be explored further.

Another set of uni-variate regression analysis has been carried out to obtain the total crop production as a function of types of land cultivated. The five types of land considered in this regression analysis as exogenous variables are:

i. area irrigated
ii. area tractorized
iii. area irrigated and using HYV
iv. area irrigated, and tractorized, and [illegible]
v. area irrigated, tractorized and using HYV

Individually, the exogenous variables listed above were regressed against the following variables :

i) total production of wheat, and
ii) total production of mustard.

Detailed information on the regression results thus obtained, is provided in the section on 'Effects of Mechanization on Crop Productivity'. These indicate that all the five variables are significant, with 99.5 per cent confidence limit and they alone explain 72-82 per cent of the variation in the explanatory variables. Also, a comparison of yields of wheat and mustard on mechanized and non-mechanized farms is made.

The findings of this exercise indicate that on an average, an acre of irrigated area yields 4.33 quintals of mustard and 7.76 quintals of wheat with the use of local/traditional variety of seeds. Corresponding numbers with use of HYV are 4.66 and 7.97 quintals, respectively. At this point, if one has to distinguish between tractorized and non-tractorized farms (irrigated in both the cases), it is observed that in the former, yields of mustard and wheat are 4.60 and 7.78 quintals, respectively for traditional/local variety of seeds; these increase to 5.30 and 7.98 quintals for mustard and wheat when HYV is used. In the latter case of non-tractorized farms, a reduction is observed in average yields of both mustard and wheat: these come down to 3.00 and 7.72 for the traditional/local variety and 4.27 and 7.92 for HYV. However, it should be noted that while on tractorized farms there is higher yield for both the crops, mustard indicates a very significant increase and wheat only a marginal one.

In Chapter 7, a comparative review of the findings of the two census surveys carried out in Dhanawas in the years 1984 and 1986 is presented. In the household sector, an increase in the average family size and decrease in per capita cattle population is observed in the year 1986. Also, per capita dung and wheat residue (stalks) available are indicated to have declined over the years 1984-86 by 4.5 and 10.3 per cent respectively; on the other hand, while potential availability of mustard residue (stalks) have been estimated to more than double over the same time period.

Average per capita and per household domestic energy consumption has been estimated to be respectively 21.5 and 24.3 per cent higher in 1986 than in 1984. In the energy consumption pattern, no significant variation is observed. Contribution of biomass fuels is estimated to have increased marginally by 2 per cent . Among biomass fuels, in 1986, firewood (logs and twigs) is found to have had much higher use in the domestic sector than in 1984, with its percentage share increasing from 3.1 per cent in 1984 to 13.7 per cent in 1986.

A comparison of the general characteristics of the agriculture sector indicates that between 1984 and 1986, per capita landholding size has declined from 0.74 to 0.68 acres. However, the percentage of land cultivated (in the Rabi season) to the total land owned is seen to be higher by 5 per cent in 1986, while the percentage of irrigated land is the same in both years.

A look at the cropping pattern indicates that a much higher area is covered under mustard and barley in 1986 while the area under wheat has reduced.

On an average, all the three crops are estimated as giving higher yields in 1986, though mustard indicates an increase of 45.7 per cent against the previously estimated yield of 3.02 quintals/acre in 1984.

Electricity is observed to contribute a higher percentage for both irrigation and threshing operations. In 1984, electricity's share has been 51.7 and 81.5 per cent of the total commercial energy consumption (i.e. excluding human and animal labour) for irrigation and threshing, respectively; corresponding numbers for 1986 are 68.1 and 91.5 per cent.

A comparison of the average energy required per acre for various operations reveals that the consumption for land preparation has increased during the period 1984-86 by 30.13 per cent; the energy consumed for irrigation is estimated to reduce considerably, from 472.46 kCal/acre in 1984 to 113.21 kCal/acre in 1986 (for electric pumpset) and 274.20 kCal/acre (for diesel). Also, the application of organic manure (dung and crop residue) on an acre of land has decreased from 12.75 quintals to 9.12 quintals in the considered time-period; use of inorganic fertilizer (urea and DAP) has indicated an increase from 0.4 quintals to 0.48 quintals.

In Appendix I, II and III, the mean standard deviation and coefficient of variation for monthly consumption of various fuels for cooking, water heating and lighting is provided. These tables indicate a high variation in the consumption pattern of various fuels among different categories of the households. However, it should be noted that comparatively, variation in the consumption of cowdung and crop-residue was much less than for firewood among biofuels and for non-biomass fuels the C.V. was ridiculously high. Also, it is observed that the consumption of cowdung and crop-residue indicates a lesser variation in the big and medium farmers' categories than small and marginal farmers and it was highest for the landless villagers. For firewood (twigs) the trend reversed, with higher coefficient of variation among big farmers than for small and marginal farmers and the least for the landless. These observations indicate high variability in the consumption pattern of various domestic fuels, depending, to a large extent on the accessibility of a particular energy source to the farmers.

Limitations of the Study

The survey was conducted only in one village in order to obtain the requisite information to plan for the current and future energy needs of the village. This study does not help in generalizing or in drawing conclusions on the rural energy patterns for the region as a whole.

To a large extent, the study does provide most of the information that one might need to work out an energy model for the considered village. However, analyses of the data and the field experience indicate a few gaps in the study. Once these limitations have been identified and clearer guidelines provided for structuring future survey efforts, the next step could be to analyze the discrepancies that arise in the data and to define methods for overcoming these shortcomings. A few of the discrepancies have been identified and are listed below:

1. While a detailed picture has been presented on the utilization of biomass resources, the survey data indicates the non-utilization of the surplus. A probable reason could be that the survey data could not differentiate between potential and

actual availability of biomass resources. For instance, dung produced per animal is one thing and dung collected per family is another. To elaborate, it is important to get information on the current collection efficiency of dung. To estimate the collection efficiency, one would need supportive information on the number of homestead animals, those taken out for grazing, and how frequently, etc. In the case of crop residue, the potential availability in the study was estimated by using the norms adopted in [4], - which estimates straw production by the weight of the grain produced. These estimates are not incorrect: however, it was very important to gauge the collection efficiency of crop residue and also to take into account the common practice of leaving stalks of certain crops standing on the field to be either grazed by the animals or to be ploughed back into the soil. It is very important that a study of this nature should also bring out the factors that influence collection efficiency, as this would be important to estimate future biomass availability.

2. There are some discrepancies in the data presented: however, the discrepancies referred to are not necessarily data errors, but are mostly the deviation of an observation from a logical trend.

Discrepancies are bound to occur in a rural set-up: however, it is important that the survey, besides identifying these anomalies, be able to provide reasons for their occurrence. The survey could not provide these reasons, it has identified the anomalies, especially in the variation trends across land holding groups of different variables. The probable reason for this could be that the size of the land owned has been taken as an indicator of the economic status of the family, which is not entirely correct. For instance, most of the discrepancies in the household sector are due to the unsatisfactory use of land holding size as a basis for distinguishing income levels or economic status. Land holding alone cannot be taken as a substitute for income as it ignores the income of a family from other sources such as service, business etc., which could be substantial especially for the landless category. However, the reasons provided in the beginning of the study for choosing the size of the land owned as a surrogate for income should be borne in mind. In a village, it is extremely difficult to get information on income and thus one would probably need more detailed information on other assets of the rural family to place it in a different economic status category. Thus, the size of the land owned is taken as one of the indicators along with others such as the number of cattle owned, the number of persons in service, the number of days of unemployment, etc. to determine the economic status.

3. In the agriculture sector, it is important to estimate energetics for an entire cropping pattern, which the study has not managed to do. Cropping patterns in the entire year influence not only the water requirement of the crops and thus their energy requirement, but also crop yields and soil

nutrients requirement. To model a rural energy system, yield water and nutrient requirement are the most essential parameters.

Attempts have been made in some sections of the report to provide reasons for the occurrence of a particular trend or deviation from the trend. However, the explanation provided does not necessarily emerge from the questionnaire but are basically observations made during visits to the village.

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APPENDIX - I

Mean, Standard Deviation and Coefficient of Variation for Monthly Consumption of Different Fuels for Cooking According to Land Owned Classification

mers' tegory	Description	Biomass								Non-Biomass					
		Dung cake (kg)		Crop-residue (kg)		Firewood-logs (kg)		Firewood-twigs (kg)		Coal (kg)		Kerosene (kg)		Electricity (kWh)	
		Per HH	Per capita	Per HH	Per capita	Per HH	Per capita	Per HH	Per capita	Per HH	Per capita	Per HH	Per capita	Per HH	Per capita
g	Mean	25.28	2.62	10.58	1.04	0.06	0.006	0.56	0.01	-	-	0.02	0.001	-	-
	S.D.	12.28	1.23	5.77	0.73	0.23	0.03	2.29	0.33			8.00	0.10		
	C.V.	48.57	46.95	54.54	70.19	383.33	500.00	408.93	3300.0			**	**		
dium	Mean	25.75	3.22	6.69	0.84	-	-	-	-	-	-	0.13	0.02	-	-
	S.D.	25.25	3.41	4.61	0.61							9.00	0.66		
	C.V.	98.06	105.90	68.91	72.62							6923.08	3300.00		
ll	Mean	17.70	2.68	6.17	0.92	0.71	0.11	1.91	0.04	-	-	neg.	neg.	-	-
	S.D.	9.06	1.33	5.07	0.93	2.33	0.44	3.99	0.59						
	C.V.	51.01	49.63	82.17	101.09	328.17	400.00	208.9	1475.0						
rginal	Mean	12.35	1.76	6.29	0.18	-	-	0.95	0.20	0.14	0.02	0.007	0.001	-	-
	S.D.	7.02	1.25	3.05	0.65			2.94	0.45	28.05	2.36	5.5	0.04		
	C.V.	56.94	71.02	48.49	361.11			309.47	225.0	**	**	**	4000		
ndless	Mean	17.56	2.22	4.24	0.68	0.28	0.04	3.87	0.43	0.105	0.02	0.03	0.005	0.02	0.003
	S.D.	11.53	1.72	8.08	1.13	1.09	0.18	4.33	0.97	32.50	2.01	3.21	0.48	13.00	0.76
	C.V.	65.61	76.58	190.57	166.18	389.29	450.00	111.89	225.58	**	**	**	9600.00	**	**
l	Mean	17.43	2.42	6.12	0.85	0.24	0.033	2.04	0.07	0.01	0.002	0.06	0.009	0.0025	0.0003
	S.D.	13.95	1.84	4.27	0.94	1.22	0.22	3.78	0.75	24.59	1.35	4.86	0.39	13.00	0.47
	C.V.	80.13	76.03	69.77	110.59	508.33	666.67	185.29	1071.43	**	**	8100.00	4333.33	**	**

te: ** indicate C.V. > 10,000 per cent.

APPENDIX - II

Standard Deviation and Coefficient of Variation for Monthly Consumption of Different Fuels for Water-heating According to Land Owned Classification

Description	Biomass								Non-Biomass	
	Dung cake		Crop-residue (kg)		Firewood-logs (kg)		Firewood-twigs (kg)		Kerosene (kg)	
	Per HH	Per capita	Per HH	Per capita	Per HH	Per capita	Per HH	Per capita	Per HH	Per capita
Mean	14.03	1.45	2.18	0.23	-	-	0.93	0.1	-	-
S.D.	7.06	0.75	1.31	0.17			0.56	0.33		
C.V.	50.32	51.72	60.09	73.91			60.22	330.0		
Mean	21.55	2.7	2.31	0.30	-	-	-	-	-	-
S.D.	9.72	1.28	0.96	0.11						
C.V.	45.10	47.41	41.56	53.33						
Mean	2.34	0.36	0.47	0.07	-	-	0.1	0.01		
S.D.	2.90	0.44	0.73	0.15			0.32	0.04		
C.V.	97.02	101.82	119.67	144.44						
Mean	12.35	1.76	6.29	0.18	-	-	0.95	0.20	0.14	0.02
S.D.	7.02	1.25	3.05	0.65			2.94	0.45	20.05	2.30
C.V.	56.84	71.02	48.49	361.11			309.47	225.0	**	**
Mean	0.98	0.16	0.13	0.02	0.02	0.003	0.08	0.01	0.005	0.009
S.D.	3.83	0.51	0.54	0.08	0.15	0.02	0.75	0.13	3.0	0.15
C.V.	390.82	318.75	415.38	400.00	750.00	666.67	937.50	1300.00	**	**
Mean	1.07	0.15	0.13	0.02	0.002	neg.	0.04	0.01	0.0001	neg.
S.D.	6.76	0.87	0.60	0.14	0.009		1.04	0.15	3.0	
C.V.	631.78	580.00	461.52	700.00	4500.00		2600.00	1500.0	**	

APPENDIX - III

Mean, Standard Deviation and Coefficient of Variation for Monthly Consumption of Different Fuels for Lighting According to Land Owned Classification

Farmers' category	Description	Non-Biomass			
		Electricity (kWh)		Kerosene (1)	
		Per HH	Per capita	Per HH	Per capita
Big	Mean	1.395	0.14	0.15	0.016
	S.D.	18.02	3.99	1.68	0.28
	C.V.	1291.76	2850.0	1120.00	1750.00
Medium	Mean	1.355	0.17	0.255	0.031
	S.D.	21.73	3.50	2.24	0.42
	C.V.	1603.69	2058.8	878.43	1354.84
Small	Mean	0.94	0.14	0.102	0.015
	S.D.	12.36	2.92	1.460	0.24
	C.V.	1314.89	2085.71	1431.37	1600.00
Marginal	Mean	0.85	0.12	0.119	0.017
	S.D.	18.19	3.44	1.41	0.460
	C.V.	2140.00	2866.67	1184.87	2705.88
Landless	Mean	0.506	0.008	0.071	0.011
	S.D.	58.80	9.74	2.67	0.580
	C.V.	**	**	3710.56	5272.73
All	Mean	0.179	0.025	0.024	0.003
	S.D.	37.55	6.60	2.17	0.460
	C.V.	**	**	9041.67	**

Note: ** indicate that C.V. > 10,000 per cent.

APPENDIX - IV

Per Capita Monthly Cereal Consumption Acording to Land-owned Classification

Unit: kg

rmers' tegory	Wheat	Rice	Guar	Bajra	Jowar	All
g	15.63	0.71	0.49	-	0.11	16.94
dium	14.90	0.58	1.92	0.29	0.08	17.77
all	11.01	0.56	0.34	1.08	-	12.99
rginal	12.18	0.51	0.31	0.02	-	13.02
ndless	9.61	0.57	0.45	-	-	10.63
l1	12.23	0.59	0.60	0.22	0.03	13.67

Production, Consumption and Distribution of Wheat Crop (Grain) by Land Cultivated Classification

Unit: Per cent of total production

rmers' tegory	Total production (quintals)	Consumed in the house	Sold	Given as wages	Saved for fodder	Saved for seeds & others
g	1290	34.26	51.94	1.09	0.16	12.55
dium	328	48.17	35.00	-	4.88	11.95
all	290	61.03	31.72	-	4.83	2.42
rginal	157	75.16	14.01	-	8.15	2.68
l	2065	44.88	42.21	0.67	2.15	10.09

Production, Consumption and Distribution of Mustard Crop (Grain) by Land Cultivated Classification

Unit: per cent of total producti

Farmers' category	Total production (quintals)	Consumed in the house	Sold	Given as wages	For fodder	For se & othe
Big	400	0.5	89.30	-	-	10.2
Medium	114	1.75	87.02	-	-	11.23
Small	53	-	100.00	-	-	-
Marginal	21				-	-
All	588	0.67	90.30		-	9.03

Production, Consumption and Distribution of Jowar Crop (Grain) by Land Cultivated Classification

Unit: per cent of total producti

Farmers' category	Total production (quintals)	Consumed in the house	Sold	Given as wages	For fodder	For se & othe
Big	444	9.28	70.50	0.90	11.71	7.61
Medium	89	16.63	60.67	-	19.78	2.92
Small	25	17.60	64.00	-	17.60	0.80
Marginal	10	20.00	60.00	-	20.00	-
All	568	10.97	68.33	-	13.30	7.34